FIELD AND LABORATORY MANUAL IN BIOLOGY

ALFRED C. KINSEY

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FIELD AND LABORATORY MANUAL IN BIOLOGY

BY

ALFRED C. KINSEY, Sc.D. (Harvard)

ASSOCIATE PROFESSOR OF ZOÖLOGY, AND WATERMAN RESEARCH ASSOCIATE, INDIANA UNIVERSITY

AUTHOR OF INTRODUCTION TO BIOLOGY

SECOND IMPRESSION

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—That it is an interesting world in which we live—

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TO THE STUDENT

Some years ago I found myself in charge of a group of boys who wanted to go exploring. They had already discovered more than I knew about plants and animals, and their imaginations ran riot when it came to inventing ways and means of making ants and flowers and worms and trees perform for their edification. I soon learned that I would be tolerated on their trips only if I covered my ignorance and went exploring with them while—occasionally—guiding them along the narrow but profitable paths of scientific method.

Now we are inviting you to continue this journey with us—the boys whose pictures are in these covers, and the thousands of young folks who have joined our company, and the great army of scientists of all ages who are always young in their ability to ask questions and their insatiable curiosity to observe which things do what, and why things do that, and what happens when we put in our thumbs and make the works go backward or sidewise or so differently that we can discover something about them.

As it was yesterday, so today it is merely my part to help you start on these laboratory and field problems. Your own eyes and imaginations will find their greatest fun in observing and experimenting beyond the bare suggestions in this manual. Your native curiosity, which you may well cultivate, may invent a dozen questions for every one I have propounded. You, all by yourself, will have to discover that I have been clumsy and all wrong in the way I have gone at some of these experiments, and that they won't work this way, but that they will work in the ingenious way you will invent. For, I repeat, I would like to explore with you, and I don't know the answers to all the questions I have asked, nor to half the questions you will ask—but together we may be able to discover them!

Let me guide only this much: If you will begin by reading through all I have suggested about each problem, you will be in a better position to avoid the mistakes that we made the first time we investigated in these fields.

If you will make a record of everything you observe at the time you observe it, your observations will be worth more than any statement based on even the youngest sort of memory.

A complete record of each problem would look something like this:

Problem Number.....

.....
(Name of problem)

OBJECT. To determine.....

(This is the thing you should keep in mind throughout all your observations on this problem.)

MATERIALS.

(This should be a list of things much as they are given in this manual.)

PROCEDURE.

(This should be a very brief description of what you did. For your record, it need not be nearly as detailed as the directions given in this manual.)

OBSERVATIONS.

(This should be a record, often in the form of a table or a simple drawing covering the results of your observations or experiment.)

CONCLUSION.

(At the end of the period, ask yourself what is the most important thing you have learned from the exercise. This is your conclusion. In a single sentence it should answer the question which was stated as the object of the exercise.)

Name.....
Date.....
Class.....

In the limited time of our laboratory periods, it may be necessary to condense our report to the following:

Problem Number.....

.....

(*Name of problem*)

OBJECT.

OBSERVATIONS.

CONCLUSION.

Name.....

Date.....

Class.....

Finally, I would add that an orderly desk in a laboratory, clean and well-cared-for equipment, and a neat—and a not too wordy notebook, seem to me some indication of orderly thinking. The way in which you do things may be of as much value to you as the actual information you obtain from your observations.

ALFRED C. KINSEY

Bloomington, Indiana
August, 1927.

TO THE TEACHER

The considerable emphasis which has been placed for some years on the importance of morphology and physiology in the course in general biology has often been justified by the statement that they were the only sub-sciences that could be utilized in an elementary laboratory. The attempt made in our INTRODUCTION TO BIOLOGY to give a bird's-eye view of seven biologic sciences is supplemented in the present manual by an attempt to prove that a workable laboratory program may be made to illustrate the principles of all of those sciences.

This manual provides for 104 (or more) double periods of laboratory and field work. Seventy-seven of these are designed for the laboratory, and thirty-one for the field (counting four that are outlined for either connection). Each outline provides enough work for the full time of a double period, the shorter exercises that are usually numbered separately in current manuals being grouped in this volume in ways that will demand the student's attention for the full period. In every case, however, the theme for each period is a unit. Only in a few cases is the work designed to extend beyond one period, and then it is enough for two full periods.

Each teacher will certainly want to rearrange the program as it is here outlined. The omission of numbers on these exercises provides for great latitude in this connection. Well-equipped city schools may want to introduce more microscope work while, unfortunately, finding it difficult to manage more than a minimum field program. Some teachers will want to use all of the work outlined in morphology and physiology, and it will be seen that the amount given will satisfy any of the state requirements, especially when it is realized that the work on sensory physiology is in the section labeled *Behavior*. Other teachers will want to omit some of these exercises. Each teacher will want to introduce exercises which, with a given class and under local conditions, may prove more valuable than anything included in this manual.

The course as outlined is designed for full-year classes beginning in the fall. Even then some schools will want to change the order of the sections in both the text and the manual to fit into the seasonal conditions and interests of the community. For full-year courses beginning in the spring, the following arrangement is suggested:

1. Introduction
2. Morphology
3. Physiology
4. Taxonomy
5. Ecology
6. Behavior
7. Genetics
8. Distribution
9. Method

PRECEPTS.—In any event, make the laboratory illustrate the same principles that are being considered by the class in the text, the recitation, and the quiz work for each week.

Remember that a real laboratory exercise is performed by the student. Demonstrations by the teacher are not adequate substitutes to the student for the chance to observe *and handle* the materials of his subject. When the small child says "Let me see it" he means "Let me feel it," as his outstretched hands testify. The making of too many scrapbooks and the tabulation of data and the mere composition work which is all too popular in some laboratories indicate some failure to understand that the basis of scientific education is the observation which the student makes with *all* of his senses.

Don't forget that you are always training average citizens and only rarely a future biologist. Keep the viewpoint of the average man, whose evaluation of science must depend upon his understanding of its relations to the other affairs of life. Said average citizen is not ready for the world of the compound microscope—where things are unnaturally large, and squeezed into two dimensions, and turned upside down—until he has learned all he may readily learn by examining the world with his own eyes. To the beginning student, Spirogyra under the microscope cannot begin to be as important as the green scum in the stagnant overflow of the meadow stream. Let us show our young students vascular bundles and chick embryos and root hairs in their normal relations, and save more detailed studies for more advanced classes.

TECHNIQUE.—Before the beginning of the year, see that the school provides the materials necessary for this course, except as supplies may be obtained from local sources. It will be necessary to plan each laboratory period several days or a week in advance. Even more time should be allowed for securing material of embryos and of live fly larvæ, and for preparing a few other exercises.

The list of materials with each exercise indicates the equipment necessary for a single student, except where otherwise indicated.

While we have aimed to reduce these exercises to the terms of a limited equipment, it will still be found possible to modify many of them for still simpler (even if less exact) methods. Indeed, my first experience came under the primitive conditions of the summer camps where the boys and girls have tried out—and invented!—many of these exercises.

Let the students help in the preparation of laboratory material. Groups may take turns in working at special hours when they can care for growing material. Such experience may be of as great profit to the student as the program of the scheduled laboratory.

Keep on hand a stock of seedlings of several sizes and of several sorts (lima beans, corn, radish, and others) for the work in morphology and

physiology. Shallow trays of sawdust or sand make convenient small gardens for indoor cultures.

Fieldwork.—Learn that the current ideas of the difficulty of handling fieldwork in biology are based on two misconceptions.

In the first place, there is the mistaken notion that every field trip need be as long and special as a picnic. The program here outlined should show that such common materials as the ornamental plantings about schools and private homes, the weed patches and the city lots and even the city streets, provide materials for trips that can be fitted into the double period of the high-school program, even if they are not the equal of the trips the teachers in suburban or rural communities may conduct.

Secondly, there is a mistaken notion that all fieldwork in biology presupposes a knowledge of the names of all the plants and animals of the region. An examination of the field trips here outlined should show how much is possible for the teacher who has as little special knowledge of scientific names as though he had never taken a course in biology.

Scientific method.—In conclusion, remember that we should be teachers of method as often as teachers of specific facts in biology. The scientist's faith in sensory observations as his fundamental source of knowledge, an attitude of wary acceptance of second-hand knowledge (authority), a consuming urge to search for the explanations, the *reasons*, the *causes* of phenomena, are the most practical things our students may acquire. This may well be the chief aim of our course. From our own methods and the methods we allow them to use, the student will in time acquire whatever attitude we own. What, then, is it we teach them?

Do we, the teachers, approach these hours in laboratory and field with the same sort of curiosity and naïve enthusiasm which we cherish in the beginning student? Do we still wonder about the greenness of the grass, the upwardness of stems, the downwardness of roots, the sidewardness of crabs, and the everythingness of everything? More than polysyllabic words and endless potherings with details, this attitude of youthful curiosity is, I maintain, the attitude which deserves to be called scientific!

Alfred C. Kinsey

Bloomington, Indiana
August, 1927.

BIOLOGICAL SUPPLY HOUSES

This list makes no pretense at being complete, and is given with the understanding that there are other firms that have excellent service. Nevertheless, the list as it stands will provide first aid for the less experienced teacher.

Allen, C.C., St. Petersburg, Fla. Marine animals, etc.
Anglers Co., 913 W. Randolph St., Chicago, Ill. Living and preserved material, microscope slides.
Biological Supplies Agency, Meadville, Pa. Living and preserved material.
Biological Supply Co., 106 Edgerton St., Rochester, N. Y. Living and preserved material.
Bowen, W. K., 1317 Pontiac St., Ann Arbor, Mich. Microscope slides and preserved material.
Brooklyn Biological Supply Co., 333 Halsey St., Brooklyn, N. Y. Fish and aquarium supplies.
Brownell, L. W., 176 E. 32 St., Paterson, N.J. A fine collection of lantern slides.
Buffalo Aquarium, 1108 Genesee St., Buffalo, N.Y. Fish and aquarium supplies.
Cambridge Botanical Supply Co., Waverley, Mass. Collecting equipment, microscope and lantern slides, etc.
Carter, George S., Clinton, Conn. Corn to show the 3 to 1 ratio.
Central Scientific Co., Chicago, Ill. Skeletons, apparatus.
Conel, J. L., South Harpswell, Me. Marine zoölogical supplies
Conrad Slide and Projection Co., Glen Ellyn, Ill. Lantern slides.
Denoyer-Geppert Co., 5235 Ravenswood Ave., Chicago, Ill. Charts, models, etc.
Elliott Nursery Co., Pittsburgh, Pa. Seeds, bulbs, perennials, etc.
Empire Laboratory Supply Co., 507 W. 132 St., New York City.
Fisher Scientific Co., Pittsburgh, Pa. Laboratory equipment.
Folz and Fuller, Inc., 417 Ninth St., N.W., Washington, D.C. Lantern slides.
Fry, Nat. P., Eureka, Fla. Live material.
General Biological Supply House, Chicago, Ill. Dissecting equipment, laboratory apparatus, live and preserved material, microscope preparations, lantern slides, etc.
Gits Co., 5419 W. Chicago Ave., Chicago, Ill. A convenient knife for laboratory use, for making sections, etc.
Hill Nursery Co., Dundee, Ill. Evergreens.
Hubert, Edward., 3615 Melpornene St., New Orleans, La. Living and preserved material.
Kny-Scheerer Co., 404 W. 27 St., New York City. Charts, models, dissecting material, apparatus, etc.
Landry, Paul A., 2233 La Harpe St., New Orleans, La. Live material.
Marine Biological Laboratory, Woods Hole, Mass. Live and preserved marine material.
McKinley Publishing Co., Philadelphia, Pa. Geographical outline maps.
Meyer, J. W. C., Oconomowoc, Wis. Biological supplies.
Milton Bradley Co., Springfield, Mass. Outline maps, other supplies.
National Audubon Society, New York City. Lantern slides, pamphlets on birds, etc.
New York Biological Supply Co., 34 Union Square, New York City.
Nielson, Alex, Venice, Ohio. Live material.
Nystrom, A. J., 623 So. Wabash Ave., Chicago, Ill., Charts and maps.

Pioneer Aquarium Co., 1801 So. Maine St., Racine, Wis. Aquarium supplies.
Powers and Powers, Station A, Lincoln, Neb. Live and microscopic preparations.
Rand-McNally & Co., New York City, Chicago, San Francisco. Atlases, pocket maps, outline maps, etc.
Republic Laboratory Equipment Co., 2106 Lamon Ave., Chicago, Ill.
Southern Biological Supply Co., New Orleans, La.
Spencer Lens Co., Buffalo, N. Y. Dissecting instruments, lenses, etc.
Sphung, A. A., North Judson, Ind. Live material.
St. Louis Biological Laboratory, St. Louis, Mo. Microscope and lantern slides.
Stephens, H. M., Carlisle, Pa. Preserved material.
Storrs and Harrison Nurseries., Paynesville, Ohio. Trees, shrubs, perennials, etc.
Wagner Park Nurseries, Sidney, Ohio. Trees, shrubs, perennials.
Ward, C. H., Rochester, N.Y. Models, skeletons.
Ward's Natural Science Establishment, Rochester, N. Y. Models, preparations, apparatus; only makers of Schmitt boxes and American Entomological Society pins.
Western Biological Supply Co., Station A, Lincoln, Neb. Microscope slides and preserved material.
Will Corporation, Rochester, N.Y. Dissecting instruments, etc.

LABORATORY SUPPLIES

The following list of supplies would equip a class of ten students for the entire set of exercises in this manual. The omission of certain exercises would considerably reduce the necessary equipment. A larger class would need a proportionately larger equipment (except for a few items of general class use).

Much of the material in these lists will be obtainable locally in all but the smallest towns. Go to the school's chemistry department or to the local druggist for the chemicals listed.

A liberal estimate of the cost of the permanent equipment (the initial cost for starting a new laboratory for ten students) is $160. This figure must vary in different parts of the country. Add $80 if a microscope is included. Part of this list of equipment will need annual replacement, especially for glassware. Less expensive substitutions could be made for a few years until the permanent equipment was accumulated.

Estimated cost of annual equipment $25.00.

Permanent Equipment from Supply Houses

1 doz.	small rules (mm. or inch)
4	sweep nets (for insects)
5	midget nets (for insects)
1	butterfly net (for insects)
1 doz.	Schmitt boxes for insects
1 doz.	cardboard insect boxes
2	small bird books (guides)
	stuffed birds or mounted pictures of birds
1	book for tree identification
10	U.S. relief (hypsometric) maps (18 x 28″)
5	Rand-McNally pocket maps of California
3 each	Rand-McNally maps of Oregon and Washington
1 each	Rand-McNally maps of all other states
40	outline maps of the U.S.
10	outline maps of the U.S. Pacific Coast
1 doz.	fine-pointed dissecting forceps
1 doz.	fine-pointed dissecting scissors
2 doz.	dissecting needles
1 doz.	shallow pans with beeswax (or paraffin) bottoms
12 ears	corn for 3 to 1 ratio
3	preserved flukes
3 each	preserved fleas, lice, bird lice, and other parasites
4 doz.	test-tubes
1 doz.	test-tube holders
2	test-tube racks
2 doz.	microscope slides
1 box	microscope cover glasses
12 doz.	vials (2 or 3 oz.) with corks

3 doz.	glass funnels (3″ diam.)
3 doz.	bottles (2¼ × 5½″)
1 doz.	rubber stoppers (with one hole) to fit above bottles
1	cork-borer
1 doz.	ring stands with clamps, rings, and gauze
2	alcohol lamps (or Bunsen burners)
3	clay crucibles
	glass tubing (small diam.)
	glass tubing (½″ diam.)
1	compound microscope
1	small incubator

Permanent Equipment Obtainable Locally

1 doz.	medicine droppers
1 doz.	pieces of glass 3 x 3″
3 doz.	pint jars
3 doz.	quart jars
2 doz.	deep dishes (enamelled)
5 doz.	tumblers or jelly glasses
5	kitchen strainers with handles
2	trowels
1	jack-knife (scout design)
1 doz.	artists' brushes, medium size
1 doz.	crow-quill pens
2 doz.	spring clothespins
5 boxes	colored crayons
3	colors of ink
2 lbs.	long wire nails
	elastic bands
1000	white beads
1000	colored beads
6 lbs.	dried lima beans
	preserved material of fungi, Indian pipe, and other parasitic plants

Annual Supplies from Supply Houses

1500	No. 3 insect pins
10 doz.	large cockroaches, preserved

Annual Supplies Obtainable Locally

15 doz.	small paper bags
4 doz.	large paper bags
6 tubes	glue
	twine
	library cards
	cross-section paper
	sealing wax (or paraffin)
	absorbent cotton
	Spaghnum moss
	bandage
	candles
	wire paper clips
	sawdust
	straight pins
	paper toweling
	old magazines with ads
	illustrated nursery catalogs
	sandy soil

	field or garden soil
	rich woods soil
	iron filings
	weak hydrochloric acid
	cyanide of potassium
	cocoanut oil
	sodium hydroxide
	alcanna tincture
	iodin solution
	laundry starch
	cornstarch
	fibrin
	pepsin
	hydrated lime
1 oz.	eosin
	vaseline
	Fehling's solution
	ammonia
	formalin (3%)
	alcohol (50 or 70%)
	marble (or limestone or washing soda)
1 pkg.	filter-paper
	seeds of corn, lima bean, etc.
	wheat flour, bread, yeast, corn syrup, and other household supplies
	potatoes, carrots, cabbage, beets, pineapple, apples, oranges, etc., in season
	vinegar
	milk, butter, eggs, pork, a hen, etc.
	living material of a potted plant, moss, fern, fern prothallia, squash stem, etc.
	live earthworms, grasshoppers, tadpoles, fish, etc.

Introduction
One field period
Kinsey BIOLOGY, pp. 1–8

OUT-OF-DOORS

Object.—To discover and observe some especially interesting plants and animals.

Materials.—None.

Procedure.—The teacher will take the class to the nearest place where numerous living plants or animals may be observed.

Discover the most interesting plants or animals you (not the teacher) can discover in a half hour (or not more than an hour). No scientific names permitted!

Vote at the end of the trip; discuss and decide which was the most interesting thing observed.

Return to the laboratory and write a short paragraph describing what *you* considered the most interesting thing observed, and explain why it was most interesting to *you*. (Or this report may be assigned as outside work.)

The following suggestions will indicate some of the things among many hundreds of possibilities that you may observe on this trip:

Ants caring for their cows
The annual rings in a cut tree trunk
A bird with unusual powers of flight
An insect visiting flowers for nectar
A spider web
An especially attractive flower
A bird with an unusual song
Some scavenger animal
An unusual fungus
A bird nest
Plants damaged by insects
An unusual insect home
An ant hill
Fine breeds of farm stock
Unusual foods in a market
A frog, toad, reptile, or fish
Large timber, lumber, or fine woodwork
Some special attempt at sanitation
A plant of unusual form
Some gall on a plant
A parasitic plant
An attractive landscape
Etc., etc.

Introduction
One laboratory period
Kinsey BIOLOGY, pp. 1–8, 122–128

LIVING THINGS

Object.—To consider some of the things that living organisms can **do,** and non-living things cannot do.

Materials.—Any living, green plant (in a pot of earth, in a jar of water, or visible out of the window).

Procedure.—The class will have a discussion and build as large a list as possible of the things that the plant under immediate observation can do and dead things cannot do. Each student will keep a record of the whole list.

Each student will independently consider the other organisms in the list below, and make as many additions as possible to the list of things that only living organisms can do.

Water-lily	Fish
Mosquito	California Big Tree
Potato plant	Worm
Fungus	Bird
Dog	Caterpillar
Typhoid germ	Elephant
Sensitive plant	Man

In conclusion, make a brief statement about the chief ways in which living things differ from non-living things.

Introduction
One laboratory period (contest)
Kinsey BIOLOGY, pp. 9–16

SEVEN BIOLOGIC SCIENCES

Object.—To learn how each of the seven sciences of biology would study a grasshopper and some other organisms.

Materials.—None.

Procedure.—Read Chapter II of the Kinsey BIOLOGY at home before this laboratory period.

The class will divide into two groups and line up as for a spelling match. Consider the following sciences of biology:

Taxonomy	Ecology
Morphology	Distributional Biology
Physiology	Behavior
Genetics	

These sciences will be named in turn, one for one side, the next for the other side, etc. It will count as a correct answer if the student can tell something that would be studied about the *grasshopper* in the science named. The question will pass to the other side if the answer is incorrect.

After a complete set of answers (for the seven sciences) on the grasshopper, the contest will continue with seven questions on each of a number of well-known organisms (for instance, a dog, daisy, pine tree, rattlesnake, man, potato).

A student giving an incorrect answer goes to the end of his line. At the end of half an hour, the order of each line will be posted. After that, students will take their seats as they give incorrect answers. At the end of the period the side with the most standing will be declared the winning side—or the last student standing wins for his side.

Taxonomy
One field period (contest)
Kinsey BIOLOGY, pp. 17–32

PLANT GROUPS

Object.—To test each student's ability to discover and recognize representatives of the main groups of plants.

Materials.—A copy of the following list of plant groups.

Procedure.—The class will go to a place with varied vegetation.

Each student will start out independently to secure one specimen of each of the following groups of plants:

Algæ	Horsetails
Fungi	Club mosses
Lichens	Conifers
Mosses	Monocotyledons
Liverworts	Dicotyledons
Ferns	

No report will be accepted during the first fifteen minutes. Then the teacher will check the list for each student as each specimen is brought in *and correctly classified.* The contest will close at an announced time (one hour or less).

Credit 2 points for each correct identification (possible 22 in above list). Credit an additional 20 points to the student first correctly completing the list (or with the most nearly complete list at the end of the period), 19 points for the student with the next most complete list, 18 for the next, etc.

Teaching Note.—The larger city parks are available for this field trip, but it will be of greater value at this stage in the course to take the class to a piece of wild woodland.

This exercise may also be run as an observation trip, for which see the outline on Animal Groups.

Taxonomy or Morphology
One laboratory period
Kinsey BIOLOGY, pp. 24–29

ALTERNATION OF GENERATIONS

Object.—To observe the alternate generations of a moss and of a fern.

Materials.—Live moss plants (or dried moss that has been soaked up in water). A fruiting leaf of a fern. A fern prothallium. A drawing pencil.

Procedure.—A. Carefully examine the material with your naked eye. Prepare to make a drawing of it.

This is not a drawing lesson, but an exercise in which you will help improve your observations by making simple outline drawings of your specimens. Never put a line in a scientific drawing unless there is a line actually present in your specimen. Omit all details except those asked for by the exercise. Make your drawings in a medium soft pencil, without shading of any kind. Do not ink-in drawings unless the teacher directs it.

Make a simple, enlarged, outline drawing of a leafy moss plant showing the root-stem, leaves, and (if present) the cluster at the top in which the microscopic reproductive organs are located. Label this drawing the sexual generation. Label the parts asked for.

Also draw the leafless stem of the asexual generation showing the spore capsule at top (probably with a cap over it). Perhaps you can discover spores in this capsule. Label the drawing.

B. Make a simple outline drawing of the leaf of an asexual fern plant. Let this show the undersurface with the spore clusters.

Also make an enlarged drawing of the prothallium of some fern, showing as many structures as can be seen with your naked eye. Label this the sexual generation.

Questions.—What are the chief differences between aternation of generations in a moss and alternation of generations in a fern?

Which generation is the better food factory in the moss? In the fern?

Which generation provides, in each case, the best means of distributing the plant?

TEACHING NOTE.—Fern prothallia are best obtained from the benches or the ground in commercial greenhouses unless the school maintains a greenhouse of its own.

Taxonomy
One laboratory period (contest)
Kinsey BIOLOGY, pp. 17–32

REVIEW OF PLANT CLASSIFICATION

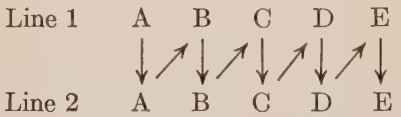
Object.—To become more familiar with the classification of common plants.

Materials.—None.

Procedure.—The class will be divided and will stand in two lines, as for a spelling match.

The first student in the first line names a common plant which the first student in the other line attempts to match with the name of the plant group to which it belongs (algæ, fungi, lichens, mosses, liverworts ferns, horsetails, club mosses, conifers, monocotyledons, or dicotyledons).

A student giving a correct answer has the privilege of asking the next question. The questions are passed in the following order:



A student giving an incorrect answer goes to the end of his line. The question then goes back to the one who asked it; he keeps his position if he can answer it correctly, but goes to the end of the line if his own answer is incorrect. The question is then dead, because it was more difficult than the questioner himself could answer.

The teacher may act as judge.

Winners are those who hold first and second places in each line at the end of the hour.

Alternative Procedure.—Instead of the above, the contest may be managed on the order of a spelling match, the teacher to ask the questions from a list of common plants prepared beforehand.

Taxonomy
One field and one laboratory period
Kinsey BIOLOGY, pp. 36–38

SPECIES, GENERA, AND FAMILIES

Object.—To determine how many species and genera are represented in a collection of leaves of trees; and to determine from the leaves, flowers, and fruits how many families of trees are represented in the collections.

Materials.—A dozen small paper bags. A couple of large bags. Cord or twine to tie the bags shut.

Procedure.—Fieldwork. Make a collection of at least 300 leaves of trees. Include leaves from as many different kinds of trees as possible, though of course there will be many duplicates. Pick the leaves directly from the trees, or gather them from the ground if you are sure they came from trees. Place these leaves all together in the large bags.

Collect as many different kinds of flowers and fruits as are obtainable at this season on the trees you are examining. Place each kind of flower or fruit in one of the small bags, together with leaves from the very same tree. Tie the bags shut so the material will not dry out too much before the next laboratory period.

Laboratory work.—Sort the general collection of leaves (from the large bags). No two leaves are exactly alike, but all the individual leaves that are very nearly alike probably belong to a single species. How many kinds (*species*) are represented in your collection, as far as you can see? Place the leaves of each species in a separate pile.

Are any two or more piles (species) so similar that you would consider they belong to the same genera? Arrange your piles by genera. Without knowing more taxonomy than we have learned to date, you will make many mistakes in this exercise, but you will get some idea of the differences between an individual, a species, and a genus.

Try to arrange the leaves in families. Now put the flowers or fruits you collected on the piles of leaves to which they belong (as far as you can tell from the leaves you collected with the fruits). Does your classification by leaves alone agree with the classification by fruits alone? Where there are disagreements, which classification are you going to follow?

Make an outline showing how many families you think are represented in your collection, how many genera are represented in each family

how many species in each genus, and how many individuals in each species.

Questions.—Define an individual, a species, a genus, a family.

What is the main advantage in *classifying* our specimens?

Did you have to have names for your specimens before you could classify them? Be careful of your answer!

Teaching Note.—In regions where the leaves of trees are not readily obtainable use the exercise on Insect Species, Families, and Orders.

Taxonomy
One field period
Kinsey BIOLOGY, pp. 48–70

ANIMAL GROUPS

Object.—To discover and recognize representatives of each of the main groups of animals.

Materials.—A pencil. A copy of the following list of animal groups:

*Sponges	Millipeds
*Polyps and medusæ	Centipedes
Flatworms	Insects
Roundworms	Molluscs
Segmented worms	Fish
*Echinoderms	Amphibia
Crustacea	Reptiles
*Horseshoe crabs	Birds
Arachnids	Mammals

Procedure.—Make the trip to a spot with as varied conditions (open field, deep woodland, brook or pond, etc) as may be conveniently found.

Stop and observe at least one representative of each of the above groups of animals. Let students identify the group represented and give in each case the key characters by which the group is recognizable.

Special credit will be due students who are first to discover representatives of new groups. Let each student check the list as each group is studied and perhaps make notes of the species, the habitat, or other items connected with the material observed.

Search under stones in ponds or on brook bottoms for flatworms and small crustacea.

Dig with sticks or other ready means for earthworms and other forms.

Search under bark, on dead tree-trunks, and under leaves on the ground for arachnids, millipeds, centipedes, insects, and land-inhabiting molluscs.

Teaching Note.—The groups with asterisks (*) need not be looked for unless the trip is along the ocean coast. In addition, roundworms large enough to be readily seen will not often be available in the open field.

Taxonomy
One or more field periods
Kinsey BIOLOGY, pp. 40–47

INSECT-COLLECTING TRIP

Object.—To learn how to make a collection of insects.

Materials.—If the laboratory is not already supplied with insect *killing bottles*, prepare them in one of the following ways: 1. Saturate a wad of cotton with chloroform, ether, gasoline, or benzene, and place it in the bottom of a small but wide-mouthed bottle which has a tight stopper.

2. Use a vial or small bottle of 50 per cent. or 75 per cent. alcohol (DENATURED AND POISONOUS!). This is the best method of killing very small or soft-bodied insects.

3. The teacher may make up cyanide bottles by putting a half inch or so of powdered cyanide of potassium in the bottom of a wide-mouthed bottle (sizes from a small vial to a pint jar are convenient). An inch or two of cotton should be packed firmly on top of the cyanide, and a slightly over-size circular disk of cardboard pushed down on the cotton. The whole should be solid in the bottom of the jar. You may use one of the cyanide jars if you remember that cyanide is deadly poisonous, a tiny grain in a cut or the stomach being sufficient to kill, and the vapor alone being dangerous to breathe. Keep the bottle tightly stoppered. Insects placed in the jar will be quickly killed by the fumes. Remove the insects from the jar at the end of each trip.

Insect nets of various sizes may be made from muslin bags fastened to a ring of heavy wire, the ends of which are twisted several times and fitted into a handle. Better nets may be bought. The school may own a set of nets, including a number of midget nets (for catching individual insects), a few sweep nets (for gathering the many insects that occur in long grass and bushes), and a long-handled butterfly net (for catching strong-flying insects).

A strong *knife* and a *trowel* are good for digging in wood or in the ground. Kitchen *strainers* with handles (from the ten cent store) are good for catching water insects.

Procedure.—CAPTURING INSECTS. A large number of insects may be collected with one's fingers, which are more convenient than a net. Only a few of the larger beetles and some bugs (especially water bugs) bite hard enough to hurt, but if they are held back of the head they cannot bite. Wasps and bees are more difficult to manage.

In using the net, remember that most insects fly upwards when disturbed. Keep them in the net by turning the mouth of the net down and letting the bag fall over the edge of the net after the insect is in it. Hold the individual insects through the cloth of the bag until you can push them into the killing bottle; or hold the bag by one corner, mouth down, while you push the bottle up into the bag and under the insect.

WHERE TO LOOK.—In tall grass.

On the flowers in a field, a garden, or an orchard.

In the air, in the open.

Under layers of decaying leaves, moss, shallow stones, boards and logs on the ground, the bark of dead tree-trunks, and other thin cover.

Inside the wood of decaying tree-trunks or boards, and inside decaying fungi.

About cattle- and horse-manure in fields, barnyards or stables, or on decaying carcasses in the open.

About cattle and horses and other stock in barns or pastures.

About decaying fruit in orchards, or exposed foods near the kitchen or in the market.

On the stems and leaves of all growing plants, especially those with succulent, tender shoots.

Inside the pithy stems of many shrubs and small trees, and especially in the stems of coarse weeds.

In the galls (abnormal growths) caused by insects on all parts of plants (*e.g.* oak apples, blackberry stem swellings, etc.).

On the surfaces of bodies of water, among the weeds of shallow waters, on the muck-covered bottoms of slow streams and shallow ponds, and especially under the stones on the bottoms of streams and of pond margins.

MAKING THE COLLECTION.—The class will make a collection of insects, securing as many different kinds as possible, but not neglecting to take a number of specimens of each kind if they are available.

Don't be in such a hurry to capture the insect that you fail to observe something of what it is doing, where it lives, etc. Biology is first of all interested in *live* plants and animals.

When the specimens are removed from the killing jars at the end of the trip, place them in pill boxes or small paper bags or envelopes to keep until you are ready to mount them. Mount them within a few days or they will become too stiff to handle conveniently.

Your day's work is not done until you have written pencil labels (ink labels spoil if they get wet) giving the date (month, day, and year), the locality (nearest post office or other geographical feature), and the name of the collector. Add any information you can about the place in which the insect was found, what it was doing, etc. Put such a label with each insect or envelope of specimens.

Save this material for the following exercise on Mounting An Insect Collection.

Taxonomy
One laboratory period
Kinsey BIOLOGY, pp. 36–38

INSECT SPECIES, FAMILIES, AND ORDERS

Object.—To determine how many species, families, and orders are represented in a collection of insects.

Materials.—A collection of 50 or more mounted insects in a box.

Procedure.—How many distinct kinds (species) of insects do you find in your box? Rearrange the specimens, separating each species, but putting together all the individuals that are almost exactly alike. Define a species.

Are there any of the species that resemble each other more than any others in the box? Place the similar species together. These groups may represent *families* of insects (the insect genera are usually hard to distinguish, and you will skip them in this exercise).

Now arrange all the families in a still smaller number of groups, as follows:

1. Those with the front wings hard and shell-like (beetles).
2. Those with only two (instead of four) wings (true flies).
3. Those with the wings colored because they are covered with fine, powdery scales (moths and butterflies).
4. Those with the hind legs lengthened for jumping and the hind wings (if present) creased and folded like a fan (grasshoppers, crickets, etc.).
5. Those with the body much flattened and very thin, and the head hidden underneath the front part of the thorax (roaches).
6. Those with the front wings thick in the front half and thin in the hind half. The mouth is a needle-like, sucking tube (true bugs).
7. Those with a pair of pincer-like forceps at the hind end of the body (earwigs).

Some of these orders may not be represented in your collection. You may also have representatives of still other orders which you should place by themselves.

Fill in a table of the following sort.

Orders	Families (by numbers)	Species (by number)	Individuals (by number)
Beetles	Family 1	Species 1 Species 2	
	Family 2	Species	

Teaching Note.—This exercise may be worked with material gathered and mounted by the students in previous exercises. Or the school may own a collection that has been made by previous classes and preserved *in Schmitt boxes*. The students may use cheaper pasteboard insect boxes while working the exercise. The commonest insects (ants, June beetles, house flies, crickets, grasshoppers, etc.), many of them in duplicate, will serve the purposes of this exercise. Each box should include a number of species represented by many specimens each, a number of species of certain families (ants, grasshoppers, ground beetles, etc.), and representatives of several of the orders listed below.

Taxonomy
One or more laboratory periods
Kinsey BIOLOGY, pp. 40–47

MOUNTING AN INSECT COLLECTION

Object.—To learn how to mount and preserve an insect collection.

Materials.—Insects collected on a previous field trip. Insect pins (size 2 or 3). Forceps. Cardboard insect boxes. Glue. A white card. A crow-quill pen. A sheet of cork is also a convenience.

Procedure.—MOUNTING. Insects may be temporarily stored in envelopes, but the permanent collection must be mounted on insect pins so that the specimens can be handled. Size 3 insect pins will be best for most insects. Specimens too small for these pins are mounted on cardboard points (described below).

Insects recently collected will be soft enough to handle without breaking. It may be necessary to place older specimens in a "relaxing jar"—which is nothing but an ordinary, wide-mouthed jar with wet sand on the bottom. A few drops of formalin on the sand will prevent mold from growing. Place the insects in the jar (on the sand, or in an envelope or small dish so they don't get too wet), and close the jar tightly. The specimens will be soft enough to handle within a day or two.

Hold the insect between the fingers of one hand while putting in the pin with the other hand. Put the pin through vertically, pushing the specimen up toward the head of the pin but allowing about three eighths of an inch for grasping the pin with the fingers. Use forceps for pushing the insects up on the pin.

Never put a pin through the joint that lies between two parts of the insect body. That would break the specimen. Put the pin through the center of the stoutest part of the body. That is ordinarily the thorax.

Beetles will need to be pinned through one of the hard shell wings, just to the right of the mid-line down which the two wings meet on the body.

True bugs (*Hemiptera*) will need to be pinned through the small, distinctly triangular piece that is attached to the hind end of the thorax.

Keep each specimen in as natural a position as possible. Specimens with slender abdomens or long legs may first be placed low on the pin so that their bodies rest on the bottom of the insect box. Then the abdomen, legs, and antennæ may be spread out (using extra pins if necessary) until they dry in position. After that the specimens may be pushed to their proper places on the pins.

Some of the butterflies, moths, grasshoppers, and sometimes other insects should have their wings spread in mounting. Sometimes the wings on only one side (usually the left side) are spread, and this saves room in the insect box. A spreading board is best to use, but a very satisfactory method is to pin the insect flat on the bottom of the insect box (or sheet cork), holding its wings in the desired position with narrow strips of paper that cross and extend beyond the wings, and then putting pins through the ends of the paper (not through the insect wings). Pin the front wings so their *hind* margins are at right angles to the body, bringing the front margins of the hind wings forward to meet the hind margins of the front wings. After a few days the insect will be stiff enough to hold its position without the paper strips.

Insects too small to pin are best glued to the tips of small cardboard points. Use a card as thick as a Library Bureau card. Cut the card into strips just about 9 mm. (a scant $\frac{3}{8}$ inches) in width. Then make crosscuts across the strip at slight angles to make slender, triangular points 9 mm. in length and about 3 mm. (scant $\frac{1}{8}$ inch) wide at the base. These points may be made more quickly and more accurately with a punch (to be secured from the entomological supply houses).

Now lay out the small insects on a clean sheet of paper so they rest on their right sides (with their wings extending to your left) and with their heads toward you. Any other position will make it more difficult to examine the mounted specimens.

Put a drop of glue on the sheet of paper (or use the glue directly from the tubes of glue now available at stationery stores). Picking up a cardboard point with the forceps, touch its smaller tip to the glue, getting a small drop of glue on the point. Then touch the point to the uppermost side of the insect. When turned over, the insect will be fastened to the point with its right side up and its head away from you. Put the insect pin through the base of the triangular point, letting the specimen extend to the left of the pin.

This is all very easy, as a little practice will prove to you. Take pride in making an orderly collection, and it will be worth it in many ways.

Labeling.—An unlabeled specimen is almost worthless for scientific purposes. Learn to put a label on every insect pin. Make the label as small as it can possibly be made and still contain as much data as possible. Too many insect collections contain more paper labels than insects. Try making labels as small as 12 by 7 mm. (a scant $\frac{1}{2}$ by $\frac{5}{16}$ inches).

Each specimen should be labeled with the locality (town and state), date (month, day, and year, written for instance like 7.4.27 for July 4,

1927), and name of collector. Add any other information you can as to the sort of place in which the insect was found, what it was doing, etc. If necessary, put two or more labels on a pin, one below the other, rather than make a single label too large. Write very clearly or print, using a sharp pencil or a very fine pen with waterproof (not ordinary) ink.

Preserving.—While your specimens may be safe for a while in cheaper cardboard boxes, they must be put finally in a nearly air-tight, so-called Schmitt box if you hope to keep certain small beetles called museum pests from getting in and eating them up. You may want to keep a few specimens in a cigar box or some other such container but you will surely be disappointed if you try to keep them for any length of time. If the school has Schmitt boxes for its collection, they will probably appreciate any gifts you care to make to them, and the classes for years to come will profit from your skill and care in mounting these specimens.

Teaching Note.—The utility of an insect collection for laboratory work and for the illustration of endless aspects of biology suggests that such a collection should be among the first things provided by the department budget. The Schmitt box (made by Ward's Natural Science Establishment, at Rochester, N. Y.) is the only convenient insect box on the market that is proof against museum pests. These boxes are expensive, but without them the collection will inevitably be destroyed by dermestids. The black japanned pin known as the American Entomological Society pin (also made by Ward's) is one of the best available. Other entomological supplies may be obtained from the same company. Metal cabinets for storing Schmitt boxes are obtainable from Brock Bros., Cambridge, Mass. or from the Cambridge Botanical Supply Co., Waverly, Mass.

Taxonomy
Two laboratory periods
Kinsey BIOLOGY, pp. 33–39

TAXONOMIC KEYS

Object.—To learn how to use a "key" for the identification of the orders of insects.

Materials.—Insects representing 6 or more orders. The key to insects given in this manual.

Procedure.—Instead of reading complete descriptions of all insects in order to decide which group is represented by any specimen we may have at hand, we may adopt a short-cut method by using a "key" to the insects.

In this key the orders are arranged according to their most important characters. Then these characters are arranged in an outline form. There are such keys published for many groups of organisms. The use of such keys will develop your powers of observation. Moreover, if you know how to use such keys, you may become acquainted, on your own initiative, with the common plants and animals of your region.

In order to see how the following key works, select a beetle (it has front wings that are hard and shell-like). Examining the key, we find this insect fits the description given under A (instead of AA); that under group A it belongs to B (instead of BB); that under B it belongs to CC (instead of C); and that under CC it belongs to DD (instead of D). Finally, we are informed in DD that our insect is a beetle (of the order whose scientific name is *Coleoptera*). Carefully follow the outline until you are sure you understand how this key works for the beetle.

Now, by this means, find the orders to which the rest of your insects belong. Write a small label for each specimen so the teacher can check your work.

The following key to insects includes almost all of those you are likely to find but there are still other orders (especially of microscopic insects) known to entomologists, and numerous species that are exceptions to the brief key characters given here. You may therefore have to use the key in some larger book to locate a few of your specimens.

Fill out a table of the following sort.

Name of order	Key characters (by which such an insect might be recognized)

A. With wings.
B. Front wings (wholly or in part) thicker than hind wings.
C. Front wings with "veins."
D. Basal half of front wing thickened, tip of wing thin and transparent.
(*Hemiptera*) **Bugs**
DD. Entire front wing thickened.
E. Mouth a needle-like, sucking beak.
(*Homoptera*) **Leaf hoppers, tree hoppers,** etc.
EE. Mouth with jaws for chewing.
F. Hind legs enlarged for jumping.
(*Orthoptera*) **Grasshoppers, crickets,** etc.
FF. Hind legs not larger than other legs.
G. Body much lengthened, front legs strong, for grasping.
(*Mantoidea*) **Preying mantids**
GG. Body oval, much flattened, all legs rather weak.
(*Blattoidea*) **Roaches**
CC. Front wings without veins.
D. With movable forceps at tip of abdomen .....(*Dermaptera*) **Earwigs**
DD. Without movable forceps at tip of abdomen ....(*Coleoptera*) **Beetles**
BB. Front wings entirely thin and transparent.
C. With two wings .....(*Diptera*) **Flies**
CC. With four wings.
D. Hind wings folded fan-like, more or less larger than front wings.
E. With stiff, hair-like appendages at tip of abdomen.
(*Plecoptera*) **Stone flies**
EE. Without such hair-like appendages.
F. Wings with hairy surfaces; rather small insects.
(*Trichoptera*) **Case flies**
FF. Wings without hairs on surfaces; rather large insects.
(*Megaloptera*) **Shad flies, dobsons**
DD. Hind wings not folded fan-like, not larger than front wings.
E. Wings coated with fine, powdery, colored scales (which can be rubbed off).
(*Lepidoptera*) **Moths and butterflies**
EE. Wings without such scales.
F. Antennæ very short, hardly visible.
G. Hind wings much smaller than front wings; with bristle-like appendages at tip of abdomen.....(*Ephemerida*) **May flies**
GG. Hind wings about same size as front wings; without bristle-like appendages at tip of abdomen .....(*Odonata*) **Dragon flies**
FF. Antennæ well developed, noticeable.
G. Head drawn out into a long beak; wings usually with a color pattern.
(*Mecoptera*) **Scorpion flies**
GG. Head not drawn out into a beak.
H. Mouth a needle-like, sucking beak.
(*Homoptera*) **Cicadas, plant lice,** etc.
HH. Mouth with jaws for chewing (or lapping).

Four wings similar in size, with many veins (especially cross veins).

J. Small, elongate, ant-like insects living in colonies; wings lying flat on body when at rest..... (*Isoptera*) **Termites**

JJ. Medium-sized to large insects living singly; wings sloping roof-like when at rest.

(*Neuroptera*) **Lace wings, ant lions,** etc.

II. Hind wings smaller than front wings, with rather few veins.

(*Hymenoptera*) **Ants, bees, wasps**

AA. Without wings.

B. Mouthparts scarcely visible, weak-bodied insects usually with bristle-like or thicker appendages on abdomen. (*Aptera*) **Primitive insects**

BB. Mouth a needle-like, sucking tube.

C. Louse-like insects from animals, mouth microscopic.

D. Body flattened (like a book lying on a table).

E. Parasites from man and other mammals. (*Siphunculata*) **Sucking lice**

EE. Parasites from birds and mammals ..... (*Mallophaga*) **Bird lice**

DD. Body compressed (sidewise, like a standing book) .. (*Suctoria*) **Fleas**

CC. Louse-like, weak-bodied insects from plants, mouth attached underneath at hind part of head..... (*Homoptera*) **Plant lice,** etc.

CCC. Free-walking insects, mouth attached at front end of head.

(*Hemiptera*) Some **bugs**

BBB. Mouth with jaws for chewing.

C. Movable forceps at tip of abdomen ..... (*Dermaptera*) Some **earwigs**

CC. Without forceps at tip of abdomen.

D. Small, ant-like insects with a thread waist between thorax and abdomen (*Hymenoptera*) Some **ants, bees, wasps**

DD. Without a thread waist between thorax and abdomen.

E. Hind legs enlarged for jumping. (*Orthoptera*) Some **grasshoppers, crickets**

EE. All legs rather weak, body oval, much flattened.

(*Blattoidea*) Some **roaches**

EEE. Legs equal, body much elongate, stick-like.

(*Phasmoidea*) **Walking-sticks**

Teaching Note.—The insects necessary for this exercise may be provided from the school collection, but are best collected by the students on a previous field trip.

More complete keys to insect orders and families may be found in the following references:

Brues, C. T., and A. L. Melander, 1915. Key to the Families of North American Insects. Bussey Institution, Forest Hills, Mass.

Comstock, J. H., 1924. An Introduction to Entomology. Comstock Publ. Co., Ithaca, N. Y.

Essig, E. O., 1926. Insects of Western North America. Macmillan Co., N. Y.

Kellogg, V. L., 1904. American Insects. Holt & Co., N. Y.

Lutz, F. E., 1921. Field Book of Insects. Putnam's Sons, N. Y.

Taxonomy
One laboratory period
Kinsey BIOLOGY, pp. 33–39

ANOTHER FORM OF KEY

Object.—To learn how to use a form of key differing from that in the previous exercise.

Materials.—The key published with the preceding exercise.

Procedure.—A key with indented margins, such as the key we used in the preceding exercise, is easy to understand; but it becomes awkward to follow when it is very large. For this reason, most recent scientific books use another form of key which is illustrated below. The wording in this key is identical with that in the previous exercise, but compare this new arrangement with that in the previous exercise.

When you understand this new arrangement, go ahead and write out the rest of *this* key, using the exact words of the other key. This is a good way in which to become thoroughly acquainted with this sort of key.

It may help you in this exercise to place the letters of the old key before the corresponding lines in this new key.

Finally, try to identify a few insects in this key and see how easily it works.

KEY TO ADULTS OF COMMON INSECT ORDERS

1. With wings 2
   Without wings . . . . .
2. Front wings (wholly or in part) thicker than hind wings 3
   Front wings entirely thin and transparent 9
3. Front wings with "veins" 4
   Front wings without veins 8
4. Basal half of front wing thickened, tip of wing thin and transparent.
   (*Hemiptera*) **Bugs**
   Entire front wing thickened 5
5. Mouth a needle-like, sucking beak . . (*Homoptera*) **Leaf hoppers, tree hoppers,** etc.
   Mouth with jaws for chewing 6
6. Hind legs enlarged for jumping . . . . . (*Orthoptera*) **Grasshoppers, crickets,** etc.
   Hind legs not larger than other legs 7
7. Body much lengthened, front legs strong, for grasping
   (*Mantoidea*) **Preying mantids**
   Body oval, much flattened, all legs rather weak . . . . . (*Blattoidea*) **Roaches**
8. With movable forceps at tip of abdomen . . . . . (*Dermaptera*) **Earwigs**
   Without movable forceps at tip of abdomen . . . . . (*Coleoptera*) **Beetles**
9. With two wings . . . . . (*Diptera*) **Flies**
   With four wings 10
10.

Taxonomy
One laboratory period (contest)
Kinsey BIOLOGY, pp. 48–70

REVIEW OF ANIMAL CLASSIFICATION

Object.—To become more familiar with the classification of common animals.

Materials.—None.

Procedure.—**A.** Conduct the contest as described for the Review of Plant Classification, using the names of common animals for questions. Classify these animals in the following groups:

Protozoa
Sponges
Polyps and medusæ
Flatworms
Roundworms
Segmented worms
Echinoderms
Crustacea
Horseshoe crabs
Arachnids
Millipeds
Centipedes
Insects
Molluscs
Fish
Amphibia
Reptiles
Birds
Mammals

B. Or conduct the contest on the order of a spelling match, the teacher to ask the questions from a list of animals prepared beforehand.

Morphology
One demonstration period
Kinsey BIOLOGY, pp. 71–77

ORGANS AND TISSUES

Object.—To observe the organs in a hen (or other animal).

Materials.—For the class: Either a hen, a fish, or a large clam (from the butcher shop). Fine scissors. Forceps. Dissecting needles. A rather deep pan of water.

Procedure.—The teacher will make the dissection. Let each student see as many as possible of the internal organs, but above all try to gain the idea that an animal is not a solid mass of living protoplasm, but a delicately constructed machine with many, many parts.

At the end of the period, let each student write a paragraph about organs, and one about tissues.

Teaching Note.—It seems well to let this first laboratory period in morphology convey ideas rather than detailed facts. Do not attempt to demonstrate details of structure, but try to show how the various organs fit into place, while naming the main systems of structures (integumentary, musculatory, skeletal, digestive, etc.).

The shock with which many students receive their first dissection may be largely avoided by using some familiar food animal *in demonstration.* Let the teacher follow the rules for dissection given with the dissection of the grasshopper. Also use whatever knowledge may have been acquired in the kitchen or at the dining table.

Keep the dissection clean. The psychological value is great. Dissect or at least demonstrate under *clean* water. If the animal has red blood, pay especial attention to keeping it clean, washing it repeatedly if necessary at the sink.

Morphology
One laboratory period
Kinsey BIOLOGY, pp. 81–83

GRASSHOPPER: EXTERNAL STRUCTURES

Object.—To observe the external structure of a grasshopper.

Materials.—A large grasshopper. A pair of forceps.

Procedure.—Find the following structures in the order given. Be ready to describe these and, more important, to explain how each one works.

Chitin.

Head.

Thorax.

Abdomen.

Compound eyes (examine with a lens).

Three simple eyes (not always present).

Antennæ. How many segments? Compare the number on the two antennæ, and compare with others in the class.

Mouthparts. How many separate parts can you count? Can you figure out the use of each?

Three parts of thorax.

Three pairs of legs. To which part of the thorax is each attached? Each leg has a number of segments which, beginning at the attachment to the thorax, are named coxa (plural is coxæ), trochanter, femur (femora), tibia (tibiæ), and tarsus (tarsi). The tarsus has several small segments. Compare the femora and tibiæ of the three pairs of legs. What function for each pair of legs?

Tarsal claws.

Wings. How many? To which parts of the thorax are they attached? What differences between front and hind wings? What functions for each wing?

Wing veins. Compare arrangement in front and hind wings.

Segments of abdomen. How many?

Auditory membrane ("ear"), on first abdominal segment just back of attachment of hind wing. With a pin or fine dissecting needle, carefully cut out the membrane and see if you can find the semicircular, thickened rim that tightens the drum-like membrane so it receives sound waves, and find the nerves that connect with this membrane. All this is difficult to see.

Breathing pores. How many? How many on each segment of the head, thorax, and abdomen? How many in all?

External reproductive organs. Compare with other specimens in the class, and distinguish male and female grasshoppers. Figure out how the four spreading tips of the female abdomen work when the eggs are laid in the ground.

After you have finished this exercise, you may review outside of class in the Kinsey Biology, pp. 81–83.

Teaching Note.—Let each student collect 3 or more grasshoppers for this and the following exercise. Kill in a cyanide jar or in a bottle with a bit of ether, or in alcohol. Preserve in 50 per cent. alcohol (in 70 per cent. if the material is to be kept more than a couple of weeks). Material may also be obtained from the biological supply houses.

Morphology
Two laboratory periods
Kinsey BIOLOGY, pp. 83–86

GRASSHOPPER: INTERNAL STRUCTURES

Object.—To observe the internal structure of a grasshopper.

Materials.—Fine-pointed scissors. Fine forceps. Two dissecting needles. A pan of water. A preserved grasshopper, as large a specimen as obtainable.

Procedure.—Learn these *rules for dissecting:* Never remove any organ until you are sure you know what it is, that you know all you wish to learn about it, and that it must be removed in order to see what is beneath. Use forceps and needles for most of the work, scraping or teasing (gently tearing) tissues to examine or remove them; don't cut with scissors (or other instruments) unless it is absolutely necessary.

With the scissors, cut off the grasshopper's wings and legs.

Using the scissors, cut the chitinous shell off the dorsal surface (the back) of the grasshopper. Start at the hind end of the abdomen, push the tips of the scissors against the inside of the shell so that they do not injure any of the internal structures, and cut along the mid-line on each side for the length of the abdomen and the thorax. Cut across the thorax just back of the head, and across the abdomen just in front of the external reproductive organs. Carefully remove the dorsal shell. Gently scrape off any of the internal organs that may remain attached to this shell before you remove it.

Place the grasshopper in the pan and cover with water. Keep under water as much as possible for the rest of the dissection.

Without further dissection, find the blood vessel that lies on the mid-line on top of the other organs. Part of this vessel may be attached to the shell you removed. Find the side valves through which the blood enters. Learn all you can about the blood circulation in an arthropod.

Without further dissection locate the wing muscles and the leg muscles in the thorax. Move the stumps of the wings and legs and carefully observe the action of the muscles. Find the lengthwise muscles that move the abdomen (some of these may be attached to the shell you removed).

With needles or forceps remove any muscles that are in the way, and examine the reproductive organs. A male grasshopper has *testes*, two

crumbly, probably yellowish masses lying toward the sides at the hind end of the abdomen. A female has *ovaries*, which may also be rather small, sack-like masses at the hind end of the abdomen, with cigar-shaped eggs packed in each sack. How are these eggs arranged? If the insect was collected near the egg-laying season, the ovaries may be so large that they will extend for the length of the abdomen and much of the thorax.

By comparing your specimen with several others in the class, make sure that you see the reproductive systems of both male and female grasshoppers.

Find the silky, stretchy, thread-like air tubes that occur everywhere among the internal organs. How do they work?

Removing the ovaries or testes with forceps or needles, examine the digestive tract. Carefully spread these organs and float them in the water without cutting or removing any part. Locate the œsophagus, the crop, the ventriculus, and the glands (gastric cæca) at the anterior end of the ventriculus. How many of these glands are there? Locate the intestine and the thread-like glands (Malpighian vessels) near the posterior end of the intestine. Now carefully cut the crop enough to show the valve inside at the posterior end. How does it work?

Make an outline drawing of the digestive tract, labeling each part.

Find the fat body, a crumbly, yellowish mass that is more or less broken and scattered among the other organs.

With the scissors, cut out all the digestive organs except the œsophagus, and find the nervous system lying mostly on the mid-line on the inside of the ventral body wall. How many swollen places (*ganglia*) are there in this nerve cord in the abdomen? In the thorax? How does the arrangement of the ganglia compare with the number of thoracic and abdominal segments? Where are the largest ganglia? Why?

Examine the nerve cord that connects the ganglia. Is it a single, solid cord? Find the nerves that spread sidewise from each ganglion. Where are these nerves largest? Why?

Find the large ganglion that lies back of the œsophagus, where the œsophagus bends to connect with the mouth. Locate the nerve cords that extend from this ganglion and around each side of the œsophagus to the larger nerve mass in the front of the head.

Cutting very carefully with the scissors, remove a piece of the external shell from the front of the grasshopper's head, below the antennæ and

between the compound eyes. Look for a knotty bundle of nerve tissue which is the largest ganglion in the body (the so-called brain of the insect). Can you find nerves leading from it to any of the sense organs? Which?

Make a diagram showing the arrangement of the nervous system.

After you have finished this exercise you may review outside of class in the Kinsey Biology, pp. 83–86.

Teaching Note.—If the dissection is not completed at the end of a period, wrap each specimen in thin cloth, including a paper label with the student's name written *in pencil*, and keep the specimens in alcohol until the next period.

This outline will serve for the dissection of a cockroach, and to a less degree for other insects. If both the cockroach and grasshopper are to be dissected, follow the outlines in the order given.

Morphology
One laboratory period
Kinsey BIOLOGY, pp. 83–86

COCKROACH: INTERNAL STRUCTURES

Object.—To compare the internal structures of a cockroach and a grasshopper.

Materials.—Dissecting scissors. Forceps. Two dissecting needles. A pan of water. A large preserved cockroach.

Procedure.—Dissect the cockroach in the same order in which you dissected the grasshopper. Learn to depend on your own skill in dissecting, and do not refer to the manual unless really necessary.

Remove the dorsal shell of the insect, and examine the internal structures from the dorsal down to the ventral surfaces. Remember not to cut or remove any organ until you are sure that you know what it is and that it must be removed in order to see what is beneath.

Fill out a table of this sort:

Cockroach Organs	Differ from grasshopper organs
Circulatory	
Musculatory	
Reproductive	
Respiratory	
Digestive	
Fat body	
Nervous	

Teaching Note.—This outline presumes the previous dissection of a grasshopper. If this is the first insect dissected, follow the outline of the previous exercise. Use any large cockroach, but preferably the West Indian or South American species that the Biological Supply houses can furnish.

Morphology
One laboratory period
Kinsey BIOLOGY, pp. 86–88

EARTHWORM: EXTERNAL STRUCTURES

Object.—To observe the external structures of an earthworm, and to observe how some of them work.

Materials.—A live and a preserved earthworm. A piece of paper toweling. A piece of glass. A small rule.

Procedure.—Find the following structures:

Head segments.

Body segments.

Egg capsule (clitellum).

Anus.

What sense organs can you find?

How many segments in front of the clitellum? Compare your count with that on at least ten other specimens in the class.

How many segments in the whole worm? Compare your count with that on at least ten other specimens in the class. Measure the length of each specimen to see if there is any relation between length and number of segments. Devise a table in which to record your results.

Find the small, bristle-like appendages on the ventral surface of the worm's body. How many rows?

Place the live earthworm on dry paper toweling and carefully note by what means the worm moves. Note the use of the bristles and the way in which the segments work.

Now compare the movements of the live worm on the dry surface of a piece of glass, on the moistened glass surface, and on moistened paper toweling. Allow the worm to remain on each surface long enough to make sure you observe normal behavior.

Write a brief description of the means by which an earthworm moves. Be ready to prove each of your statements by your own observations.

Teaching Note.—In most suburban and rural communities each student may be depended upon to provide two or three earthworms for this and the following exercise.

Morphology
One laboratory period
Kinsey BIOLOGY, pp. 86–89

EARTHWORM: INTERNAL STRUCTURE

Object.—To observe the internal structure of an earthworm.

Materials.—Scissors. Forceps. Two dissecting needles. A pan of water with a cork, paraffin, or beeswax bottom. A dozen straight pins. A large preserved earthworm.

Procedure.—Using scissors, cut through the skin of the earthworm on the mid-dorsal line for the entire length of the body. Keep the points of the scissors pressed tightly against the skin, pointing them upward so that no internal organs are cut.

Spread the skin to each side, being careful not to tear any of the internal organs, and pin it through the edges to the paraffin bottom of the pan of water.

Note the cross partitions that divide the body cavity. Does the arrangement of the partitions exactly agree with that of the external segments?

Find the dorsal blood vessel, and the anterior blood vessels that pump the blood. Later in the dissection you may find a ventral, longitudinal vessel. Note the color of the blood. Remember this is a *closed* circulatory system.

Locate some of the several reproductive structures near the head end of the animal in the 9th to 13th segments. The true reproductive glands (ovaries and testes) are smaller structures more difficult to find in this animal.

Can you locate the circular and the lengthwise muscles that lie inside the skin of the whole body?

Where are the respiratory organs?

How does the digestive tract differ from that of an insect? Find the pharynx, œsophagus, crop, gizzard, and intestine. How many of these parts show, externally, segments corresponding to the segments of the skin of the worm? Carefully cut the digestive tract lengthwise. How many parts of the tract show segments internally? What is the real food of the worm? (Be careful of this last answer!) Can you figure out the function of each distinct part of the digestive tract?

Locate two small kidneys (*nephridia*) in each segment on either side of the intestine. In how many of the segments of the body do you find these excretory organs?

After you have finished this exercise, you may review outside of class in the Kinsey Biology, pp. 86–89.

Teaching Note.—As outlined, this exercise presupposes the dissection of the grasshopper or cockroach. If the earthworm is the first animal dissected by the class, see the rules for dissection given for the grasshopper.

Morphology
One field period
Kinsey BIOLOGY, pp. 94–102

WOODY PLANT STRUCTURES

Object.—To observe how the structures of woody plants function under natural conditions.

Materials.—For the class: A jackknife.

Procedure.—Let us go out where we may observe some woody plant (tree, shrub, or stout herb) growing under natural conditions.

Somewhere in the course of the trip it will be desirable to locate a smoothly cut stump of a tree for observation.

Note the distinct parts of the plant: its leaves, branches, main stem (or trunk), and roots. What is the function of each? Can you see how each serves in the growing plant we are observing? What would happen to this plant if any of these parts were destroyed by insects, fungi, decay, injury, or other means?

Leaves.—In what ways are these leaves serving the plant? What animal organs have most nearly the same functions? How do you know these leaves are making food for the tree? Have you ever had proof that they are doing most of the breathing for the tree?

Are all the leaves that you see green in color? Why are most of them green? Why have some of them turned color? If it is late in the fall, can you explain why the leaves are turning color?

What advantage is it to have the leaves thin and flat? Can you find some kinds that are thicker than others? What advantage is each kind to a plant?

How many different shapes can you find among leaves? Which is the best for manufacturing food? Which is best protected from winds? From snows? From cattle and insects and other enemies that would eat it? From cold, drought, hot sun, or other extreme conditions. Don't fail to examine the leaves of any evergreens you may come across.

Can we learn to distinguish compound and simple leaves? Look for the buds at the base of each leaf on a bush or a tree.

What is the function of the veins in leaves? What are the chief differences in the way the veins are arranged in these different kinds of leaves?

Examine the buds on this tree. Cut one open and discover what you can about its structure. Compare the buds on different kinds of plants.

Why do they differ so in size, covering, shape, etc., in these different plants?

Stems.—What are the chief functions of most of the branches of a bush or tree? Can we find any cases, here in the field, of stems that are unusually successful in performing their functions? Of stems that are failing to perform their function? In the latter case, what is going to be the result to the plant?

Find side stems that are "alternate" in their arrangement on the main branch? And stems that are "opposite." Can you find both kinds on a single sort of bush or tree? Let the whole class discuss this.

Now examine the arrangement of the *leaves* on a stem. Are they always alternate or opposite on a given tree?

What relation is there between the position of a leaf and of a branch? Now you have a fine chance to prove you have eyes! Don't guess at the relations of leaves and branches, don't stand off a distance and wonder about it, but take hold of one of those stems and, with your own eyes, discover this relation. It is worth spending some time until we discover this without help from anyone.

Look now at the main trunk of this tree. How does its structure differ from that of a side branch of the same tree? How does its *function* differ from that of a side branch?

Let us find a smoothly cut stump of some tree. Then we can see the relations of the *bark*, the *cambium layer*, the *sapwood*, the *heartwood*, and perhaps of the central *pith*. Can you tell the function of each part?

Let us examine the *rings* of annual growth. Can you explain just how they are formed? Let us count them in this tree. Let us by all means try to find other stumps, and compare results in different kinds of trees and in different individuals of each kind. May you never grow so old that you lose the desire to count the rings in every cut stump you see!

Where in this trunk did the water go up? And where did the food-laden sap come down?

Try to find some place along a fence-row where a wire has been wrapped around a growing tree at some time in the past. As the trunk grew, the wire interfered with the circulation in the stem. How has this changed the shape of the stem? What does this prove about the direction of sap flow?

Roots.—Let us try to find some roots that are exposed enough to examine. How do they differ from stems in structure? In function?

Find outstanding cases of roots serving to anchor plants in position.

Of roots that have failed in this function. Here, take a hold of even this weed with both hands and pull it up, roots and all. Now have you more respect for roots?

—Well, you see I can still ask questions, even though it has been some years since I first asked them about plant structures. I hope you have learned the fun of asking questions about even very common things out-of-doors.

Morphology
One or more laboratory periods
Kinsey BIOLOGY, pp. 94–102

VASCULAR BUNDLES

Object.—To determine the arrangement and function of the vascular bundles in plants.

Materials.—For the class: Eosin (or red ink). Carrots, (or turnips or other fleshy roots, preferably with stems and leaves attached). A young stem (or seedling) of corn. A dicotyledonous stem with leaves (squash, sunflower, or geranium). A *young* squash (or pumpkin, cucumber, or melon of other sort). Small cabbage or lettuce heads or Brussels sprouts.

Procedure.—For several days the teacher has been keeping a number of plant structures in water which is stained red with eosin (or red ink). Enough of this dye has now circulated through the plant tissues to show the paths along which the water travels. These special tissues which carry both the upward flow of water and the downward flow of sap are the so-called vascular bundles of higher plants. In the leaves they are more often called veins.

Examine the vascular bundles in each of the available plant materials. In each case note the position, the size, and the form of the bundles. Make your study in the following order as nearly as you can secure the material.

A. A root (carrot, turnip, etc.) cut lengthwise. Make a very simple drawing showing where the bundles are in this.

B. A root cut crosswise (in cross-section). No drawing is necessary here.

C. A stem of a dicotyledon (squash, sunflower, or geranium) in cross-section. Make a very simple drawing showing this arrangement of bundles.

D. A monocotyledon stem (corn) in cross-section. Make a very simple drawing showing the arrangement of these bundles.

E. A whole leaf from a head of cabbage (Brussels sprouts or lettuce). Hold it up to the light. Slice off a thin layer from the thickest part of the leaf in order to expose the bundles in it. Make a very exact drawing of the

bundles in not more than one square inch of the thinner part of one of these leaves.

F. A lengthwise slice of a squash (or melon). Note the extension of the vascular bundles to the seeds. No drawing necessary.

In a single brief paragraph, write a description of the vascular bundles of higher plants. What is their function?

Teaching Note.—Two or 3 specimens of each of the plant materials will provide for the class. Circulate the material in the course of the hour.

Make this a study in gross anatomy. To get an idea of the general scheme and function of the vascular structures of higher plants will prove more practical knowledge to the beginning student than a study of microscopic cross-sections.

Two days before this laboratory session, the teacher should place the roots, the cabbage (lettuce, or Brussels sprouts) and squash (or melon) with their stem ends in water in which enough eosin has been dissolved to make the color a rather deep red.

About a day before this session, the stems (or seedlings) should be placed with their ends in the same eosin solution. If these specimens have been freshly cut, they will circulate enough of the eosin to show up the vascular bundles to great advantage.

Morphology or Physiology
Two laboratory periods
Kinsey BIOLOGY, pp. 98–99

OSMOSIS

Object.—To observe several instances of the way in which osmosis acts.

Materials.—For two students: An egg shell (or its inner membrane). Vinegar. Strong sugar solution (boiled). Table salt. Nut shells (peanut, walnut and others). Sugar. Part of a fresh beet. A fairly large carrot. A stopper to fit the carrot (see below). Sealing wax (or paraffin). Five tumblers. Two shallow dishes. Glass tubing. An elastic band. A ring stand with clamp (or a spring clothespin and any solid upright). A rule.

For the class: Several knives. A cork-borer. A flame with a ring stand or tripod.

Procedure.—**A.** Carefully pick away the shell from one of the eggs that has been in vinegar, aiming to secure a membrane without holes except the one made at the large end. Through this hole insert a glass tube, fastening the membrane with three or four turns of an elastic band. Gently blow through the tube, and if this shows any holes in the membrane you will have to discard it. If the membrane is solid, pour in enough strong sugar solution (that has been boiled) to fill the membrane completely. Place in a tumbler of pure water so the membrane is completely covered, but do not let it touch the bottom or sides of the glass. Support it by fastening the glass tube to a ring stand (or other firm upright). Get several opportunities in the next three or four hours, and once or twice in the next day, to note the rise of the liquid in the glass tube. Measure the height of the column and record the time of each observation.

B. Insert the end of a long glass tube through a cork or rubber stopper, making the hole with a cork-borer or scout knife. Dig out the center of a carrot, making sure that there are no holes through the side walls of the root, and making the opening at the top the exact size of the stopper with the glass tube. Put in the stopper, make all joints watertight with melted sealing wax or paraffin, pour enough strong sugar solution through the tube just to fill the carrot and set up in a tumbler of clear water. Get several opportunities in the next two days to note the rise of the liquid in the glass tube.

C. Cut 3 thin slices of a fresh beet. Place one in pure water and one in

salt water. Cover one with dry salt. At the end of the period, compare the degree of flexibility of the three pieces. Can you explain why each is different from the others?

Before you leave the class, wash thoroughly the two pieces that have been acted on by salt, and set them aside in pure water with a label bearing your name. Get time in the next day or two to see the effect of this treatment.

D. Prepare half nut shells that have no apparent holes in them, using two halves of each of as many different kinds as are available. Keep the shells dry inside. Place a little granulated sugar in each, using equal quantities per shell. Float one shell of each kind on pure water, and one shell of each kind on strong sugar solution. Note the time when the last grain of sugar in each shell is dissolved.

Question.—Can you now describe one of the forces which causes water to flow from the soil into the roots of plants, and from cell to cell and upward in plants?

Teaching Note.—A few hours before the class meets, prepare the egg membranes by breaking holes in the large ends of the eggs, cutting a small hole through the thick membrane that lines each shell, and pouring out the egg contents. Place the shells in vinegar where, in the course of about three hours, the shell will be eaten enough to be removed without injury to the membrane.

Be sure that parts A and B of this exercise are set up before the end of the first period.

Morphology
Two laboratory periods
Kinsey BIOLOGY, pp. 116–121
Requires early preparation

CHICK EMBRYOS

Object.—To observe the gradual development of the chick embryo.

Materials.—For the class: Forceps for each student. Twenty-one (or more) broad but low tumblers. A quantity of cotton (or other padding). Enough normal salt solution to fill 21 tumblers or more. At least 21 hen eggs, including 3 or more that are "fresh" and 3 or more of each of the following: eggs that have been in the incubator (or under a hen) for 24 hours, for 2 days, for 3 days, for 4 days, for 10 days, and for 15 days. These eggs should have stood upright (small ends down) for a couple of hours before the class period.

Procedure.—Remember you are handling delicate, live material—so proceed carefully.

Let each student hold an egg upright, with the little end down and the broad end up.

The yolk in an incubating egg will slowly revolve, finally bringing the embryo uppermost in whatever position the egg may lie. There is an air space under the shell at the *large* end of the egg, and if you remove the shell at this end there is less chance of doing damage to the contents. For these reasons, these eggs have been kept upright, large ends uppermost, long enough to allow the embryo to come into this large end.

Tap the broad end rather sharply until the shell begins to crack.

Place the egg upright (large end still up) in a tumbler, holding the egg in position with cotton or other padding. Put enough padding in the bottom of the tumbler to bring the upper end of the egg within an inch or so of the rim of the tumbler. Cover the egg with salt solution of moderate temperature (as warm as or slightly warmer than room temperature).

Using forceps, break out the cracked shell in small bits, until there is a hole the size of a quarter at this broad end. Do not break the thin skin that lines the inside of the shell of the egg until you are ready to break it to see what is beneath. Be careful never to break the very thin membrane that surrounds the yolk.

Now you should be able to see the "germ spot" or chick embryo lying on one side of the yolk. If for any reason the embryo has not come into position at this end of the egg, you may (especially in older eggs)

have to break away some of the shell on one side, working now with the egg in a pan of water.

Let each student examine at least one specimen of a fresh egg, and one of each of the eggs 1, 2, 3, 4, 10, and 15 days old. Note any differences that may be observed in eggs that are supposed to be of the same age in development. Take plenty of time to see everything you want to see. What is the most interesting thing about it all? Take time to discuss every question you have with the teacher and the class.

Make very simple outline drawings (without too many details) of one of each type of egg, showing such of the following structures as can be seen with the naked eye.

1. Fresh egg. Show the germ spot, which is the living protoplasm from which the embryo will develop.
2. One-day embryo. Which is head end?
3. Two-day embryo. Note any blood vessels of the developing yolk sac.
4. Three-day embryo. Find the heart.
5. Four-day embryo. Label eye, fore limbs, and hind limbs.
6. Ten-day embryo. Label all structures you can identify.

Explain what we mean by the gradual development of an organ in an embryo, using your observations on the chick as illustration.

TEACHING NOTE.—While this exercise requires more than ordinary preparation it will prove invaluable in teaching what are (for the average man as well as the scientist) some of the most important ideas in biology.

The cheapest sort of incubator, such as a mail order house furnishes for eight or ten dollars, will work well enough to prepare this material. Place the eggs in the incubator, 15, 10, 4, 3, 2, and 1 day before they are required. Mark each egg prominently with the number of days it has to incubate.

Normal salt solution is water made "as salty as teardrops."

To keep the embryos alive until the second period, cover each tumbler which contains an egg with a large fruit jar or bell jar. In this position the embryos may be kept alive (and may grow) for at least two or three days.

Morphology
Two or more laboratory periods
Kinsey BIOLOGY, pp. 102–105

FLOWER STRUCTURES

Object.—To observe the parts (organs) of several flowers.

Materials.—Three or more kinds of cut flowers in water. Forceps. Several penknives for the class.

Procedure.—Examine the parts of the flower, and identify:

Calyx	Anther
Sepal	Pollen
Corolla	Pistil
Petal	Stigma (on top of pistil)
Stamen	Style
Filament (of stamen)	Ovary

Make some sort of floral diagram showing the numbers and arrangement of all the parts of the flower you are studying. Invent your own ways of making these diagrams, but show by simple lines all of the parts to be found in this flower and how many there are of each part.

Note whether the sepals are separate or joined together, whether the petals are separate or joined together, and where the stamens are attached.

Examine and make diagrams of as many more flowers as you have time to study.

Questions.—Is there any simple mathematical relation between the number of parts of each kind of structure in the flower? With this in mind, you will be interested in examining many other kinds of flowers as you come across them in the field.

Describe the work that each part of the flower does for the plant.

Are the parts of a flower similar to the organs of an animal? Explain.

Teaching Note.—In most communities the students may be depended on to bring flowers. In the fall, the species available for this work differ considerably in different parts of the country. Try to secure flowers of some size, showing all of the floral parts. *Avoid* composites (daisy, aster, goldenrod, etc.) for this initial study. In the spring, try similarly to find a flower with all the parts instead of the classic tulip.

Morphology
One laboratory period
Kinsey BIOLOGY, pp. 119–121
Requires early preparation

EMBRYOLOGY OF A DICOTYLEDON

Object.—To observe gradual development in the embryo of a dicotyledon.

Materials.—A lima bean seed that has been soaked overnight. One bean seed that has grown in sand for about 24 hours, one 2 days old, one 4 days old, and one about 8 days old.

Procedure.—Examine a soaked bean. Make a very simple drawing of the outside of the bean, showing the scar (*hilum*) by which it was attached in the pod.

Split the bean carefully and discover the embryonic structures that lay between the two halves and are now attached to one half. Make a very simple drawing at least twice natural size, showing (and labeling) the following:

Seed coat
Seed leaves (two cotyledons)
Caulicle (the embryonic stem and root)
Plumule (the embryonic foliage leaves)

All of these except the seed coat are part of the embryonic bean plant whose development began before the maturing of the seed.

Examine the series of bean seedlings of various ages, and make a simple drawing of each. In each case identify and label the structures listed above until you can name a definite stem, root, and foliage leaves.

Questions.—Which of the plant structures have you now observed arising by *gradual* development?

Where does the bean embryo get its food before it has foliage leaves large enough to manufacture the food?

How do you know where the food of the bean embryo is located?

Teaching Notes.—The teacher should prepare for this exercise by planting about twice the desired number of beans 8 days before they are needed, and similar amounts 4 days, 2 days, and 1 day before they are needed. In each case, soak the beans an hour or two before planting them in a box or drained pan, on moist sand or sawdust. Have a set of soaked but not planted beans also ready for the class. Use beans bought as seed, not the dried lima beans of the market.

Morphology
One laboratory period
Kinsey BIOLOGY, pp. 119–121
Requires early preparation

EMBRYOLOGY OF A MONOCOTYLEDON

Object.—To observe gradual development in the embryo of a monocotyledon.

Materials.—Corn seed that has been soaked overnight. A seed that has grown about 24 hours, one 2 days old, one 4 days old, one 8 days old. A couple of penknives for the class.

Procedure.— Make simple drawings of the outside of the grain of corn and of a grain cut lengthwise (across the narrower dimension). Locate the seed cover, caulicle, plumule, seed-leaf (nearer the plumule and caulicle), and a new structure called the endosperm (clear in sugar corn; partly yellow and partly floury in field corn).

What are the chief differences between the corn and bean seeds?

Examine the series of corn seedlings of various ages. Note the chief differences from the bean seedlings of similar age. Make a series of simple drawings *or* write a brief report (as the teacher may direct).

TEACHING NOTE.—As with the previous exercise, prepare this material by planting soaked seed in sand or sawdust 8, 4, 2, and 1 day before its use.

Physiology
One laboratory period
Kinsey BIOLOGY, pp. 129–132, 135–136

SUGARS AS FOODS

Object.—To prove the presence of certain sugars in plant tissues, and to discover how sugars are digested.

Materials.—A little corn syrup. Fehling's solution. Fresh plant tissues of many sorts: seeds, (beans, corn, peas, radish, etc.), fleshy roots (carrots, turnips, etc.), growing stem and leaf tissues (seedlings are good), fruits (juices and solid parts, apples, pears, oranges, lemons, melons, etc.), and the tips (stigmas) of pistils of larger flowers. Two test-tubes. A test-tube holder.

For the class: Several alcohol lamps (or Bunsen burners or other flame).

Procedure.—**A.** A TEST FOR CERTAIN SUGARS. Recall the taste of sugar. That is an adequate test for a sugar if it is present in sufficient quantities.

For smaller amounts of certain kinds of sugars that occur in plant tissues, we may use this test. Mix a bit of corn syrup in a little water in a test-tube. Add Fehling's solution and boil for a moment or two. To obtain a marked result it may be necessary to let the solution stand for a time. The color of the resulting sediment is, so chemists tell us, an indication of the presence of grape sugar and some other kinds of sugar found in plant tissues. Cane sugar has to be tested by other tests which we will not try now.

B. SUGAR IN PLANT TISSUES. Use the Fehling solution test on as many plant tissues as are available. Many tissues that contain sugars at certain times do not contain sugars at other times, so do not expect positive results for every tissue. Solid tissues like seeds, apples, etc., should have thin slices cut for the Fehling's test.

C. DIGESTION OF SUGAR. Does sugar dissolve in water? It is, then, a simple matter for most plant and animal tissues to take up sugar solutions for use as food; and we need make no experiments to show how sugar is digested.

Questions.—How abundant do sugars seem in plant tissues?

Where do animals get the sugars they use as foods?

What do you mean by *digestion* of a sugar (or any other food)?

TEACHING NOTE.—Fehling's solution may be obtained from the druggist. The two solutions should not be mixed until just before they are to be used.

Physiology
One laboratory period
Kinsey BIOLOGY, pp. 129–132, 135–136

STARCHES AS FOODS

Object.—To prove the presence of starch in plant tissues, and to discover how starch is digested.

Materials.—Iodin (either the tincture of iodin, or potassium iodide solution). Laundry starch. Cornstarch. Fresh Fehling's solution. Two test-tubes. A medicine dropper. Soaked seeds of bean (and other plants). Seedlings of beans (or other plants). A bit of wheat flour. A piece of raw potato.

Procedure.—**A.** The test for starch. Dissolve a very small bit of laundry starch in water, put in a test-tube with more water, and heat until clear. Then add a drop or two of the iodin solution (or tincture).

Put a drop of the iodin solution (or tincture) on a piece of dry starch. The color is really the same as in the starch solution, but now so intense it looks nearly black.

This color resulting from the application of iodin is, according to the chemists, positive evidence of the presence of starch.

B. Starch in plant tissues. Apply a drop or two of the iodin to the freshly cut or broken surface of a bean seed. Give it time to soak in. Does the reaction indicate the presence of starch? Try as many other kinds of seeds as are available.

If seedlings of beans, corn, or other plants are available, cut the whole of a plant lengthwise and try the iodin test on the whole cut surface.

Try the iodin test on wheat flour.

Try the iodin test on the freshly cut surface of raw potato.

C. Digestion of starch.—Chew a bit of raw potato. Notice its tastelessness (typical of starch). Let the potato remain in the mouth for a few minutes where the saliva can reach it. Now what is its taste? What does this show?

Place a bit of boiled starch paste in a test-tube with saliva and hold the tube in the hand so it is kept at body temperature for several minutes. Test half of the mixture for starch (iodin test). Test half of the mixture with Fehling's solution for sugar (as in the previous exercise). Does

the starch now show the same composition as it did before the saliva reached it?

In the higher animals the digestion of starch is begun by the saliva in the mouth and continued by other enzymes in the small intestine. Digestive enzymes with similar properties are also found in plants. The sugars resulting from starch digestion are soluble in water and pass readily into the cells of living plant and animal tissues where they can be used as food.

Physiology
One field period
Kinsey BIOLOGY, pp 122–161

SOME PHYSIOLOGIC PROCESSES

Object.—To make field observations on some important physiologic processes.

Materials.—For the class: A couple of trowels (or other digging implements).

Procedure.—Since no textbook descriptions satisfactorily substitute for the chance to see things out-of-doors, we are going to observe some of the processes by which foods, and protoplasms are built up and used by the living plant or animal as the source of its energy.

Make the trip anywhere in the open.

Look for examples of physiologic processes. Don't forget that even the simplest and most common things may be worth considerable attention and thought.

PHOTOSYNTHESIS.—Look for conditions that concern photosynthesis. Notice how much green material there is in the world. Think of the carbon dioxide that is being used up by these plants, and the oxygen they are giving out.

Is the sun shining? How important is this for photosynthesis? Is it a cloudy day? What effect does this have on photosynthesis? Do you fully realize how completely dependent we are on the existence of sunshine?

Try to find some plants that are not green (fungi, molds, Indian pipe, etc.). Are they carrying on photosynthesis? Where are they getting their food? Why?

Chew a grass stem, or a seed of some grain, or a fruit. Did its sugar come from the soil? From the air? From elsewhere?

Do you realize how completely the existence of the animal kingdom is dependent upon green plants such as we see about us?

NITROGEN FIXATION.—Think of the 80 per cent. of nitrogen there is in the air, and realize how difficult it is for organisms to get it out of the air.

Loosen the soil about a clover plant and carefully dig it up. Look for the bacteria nodules on the roots. What do these have to do with nitrogen fixation?

Dig up as many different kinds of legumes as you can find. The list may include alfalfa, beans, several clovers, sweet clovers, peas, lupines,

vetch, peanuts, and others. Compare the nodules on the different kinds of plants. Are there great differences among the individuals of any one kind.

If you are in a farming region, see how much clover the farmers may have planted. What will they do with it?

If you can observe gardens or farming operations, notice the use being made of fertilizers. These are used mostly for the nitrogen and mineral foods they contain. There are many kinds of fertilizers in use. What kinds are used in this region?

Destructive metabolism.—Of how many of the four processes—respiration, fermentation, waste, and decay—can you find actual instances? Look for especially interesting cases of each.

Energy released.—Can you find actual cases of motion, heat, light, electricity?

By all means watch some strong-flying bird like a chimney swift, swallow, hawk, buzzard, or humming bird, and take plenty of time to realize how much energy is being released by its metabolistic processes!

See how busy the birds are hunting food to keep up their rapid metabolism. What kinds of animals can you find that are not very busy food gathering? Why is it so with them?

As we hiked more briskly, did you notice how much warmer you became? Can you explain exactly where this heat came from? Make your answer as complete as possible.

Secretions.—Let us take a few minutes to look for some of the more unusual products of metabolism: Wood, nectar, odors of leaves and flowers, etc., among plants. Spider and caterpillar silk, the wasp's paper nest, saliva, the ant's poison spray, etc., among animals. All of these have been derived by remarkable metabolistic processes from the foods these organisms use.

For a report, make a list of the most interesting things you have observed on this trip.

Physiology
One laboratory period
Kinsey BIOLOGY, pp. 133–136

FATS AS FOODS

Object.—To prove the presence of fats in plant tissues, and to discover how fats are digested.

Materials.—A bit of butter. Sodium hydroxide. Cocoanut oil. Alcanna tincture. Seeds of several sorts (bean, peanut, peas, radish, corn, oats, barley, cottonseed, various nuts, or others). Buds of several trees (maple, linden, hawthorn, lilac, or others). A glass slide (or shallow dish). Sheets of clean white paper. A test-tube. A medicine dropper.

For the Class: Several pocket or paring knives. Several alcohol lamps (or Bunsen burners, or one oven).

Procedure.—A. The tests for fat. Place a bit of butter (or other well-known fat) on a piece of clean, white paper, and hold over a low flame, making very sure to keep it high enough to avoid burning the paper while the fat melts. (Instead of this, you might put the paper in a warm oven.) The resultant grease spot is a good test for the presence of a fat.

Place a bit of butter on a glass slide (or in a shallow dish). Add a few drops of the alcanna tincture. The resultant color is obtained only when the alcanna tincture is put on a fat.

B. Fats in plant tissues. No one needs proof that fats occur in such animal products as milk, butter, lard, and fat meats. We shall, however, take time to prove its presence in some plant tissues.

Scrape and cut into fine bits a seed or two of as many different species as are available. Place about half of the meal from each seed in a pile by itself on a piece of clean, white paper. Hold the paper high above a low flame (or put it in an oven) until it is hot enough to indicate by grease spots whether there is fat in any of these seeds.

Place the remaining half of each powdered seed on a glass slide and test with alcanna solution for fats.

Try this test on the surface of a seed of corn that has been cut crosswise.

Test freshly cut surfaces of live buds of trees with alcanna solution.

C. Digestion of fat. Put a little cocoanut oil in a test-tube, add water, shake until the mixture is milky, allow it to settle, and note results. Now add a few drops of an alkali (sodium hydroxide) to the

mixture, shake again, and allow it to settle. Compare results. The alkali has made the fat and water into an *emulsion.* One of the digestive juices (the pancreatic juice) of higher animals is an alkali that emulsifies fats so that they are water-soluble and can be taken up by the cells of the animal's body.

Now put some melted cocoanut oil in a clean test-tube and add quite a little of the alkali (sodium hydroxide), shaking well meanwhile until a solid substance forms. Go to the sink and rub this solid substance on your hands while they are wet. What is the solid substance? The pancreatic juice thus makes the fats of our foods into a similar solid that is soluble in water and can then be taken up (assimilated) by living cells.

What do you mean by the *digestion* of a fat?

Teaching Note.—Sodium hydroxide, cocoanut oil, and alcanna root are obtainable at drug stores. Alcanna tincture is made by soaking the root in alcohol until the coloring matter is extracted.

Physiology
One laboratory period
Kinsey BIOLOGY, pp. 133–136

PROTEINS AS FOODS

Object.—To prove the presence of proteins in plant and animal materials, and to discover how proteins are digested.

Materials.—Hard-boiled white of egg. Milk. Fibrin. A bit of fresh, uncooked pork. Pepsin solution. Pancreatin solution. Various seeds (beans, pea, corn, etc.). White bread. Whole wheat bread. A squash or pumpkin stem. Four test-tubes. A medicine dropper. Juice of fresh pineapple.

For the class: Nitric acid. Ammonia. Alcohol.

Procedure.—A. The test for proteins. The white of a hen's egg is a relatively pure form of protein. Place a bit of hard-boiled white of egg in a test-tube. Add a drop of nitric acid (be careful not to spill this acid) to the white of egg, and then a drop of ammonia. The resultant color is a good test for the presence of a protein.

B. Proteins in plant and animal materials. You have already tested one animal material for protein. Test a little milk, fibrin (one of the materials from vertebrate blood), a bit of fresh pork, and any other animal materials that happen to be available.

Try the protein test on the freshly cut surfaces of several kinds of seeds, a bit of whole wheat bread, then on a bit of white bread, on the freshly cut stem of a squash or pumpkin (which is first laid in alcohol for a time before testing for protein), and any other plant materials you care to test.

C. Digestion of proteins. Place a bit of fibrin in each of 4 test-tubes. To one add a little water, to another a solution of pepsin, to a third a solution of pancreatin, and to the fourth some juice of a fresh, uncooked pineapple. Label and set all these aside (they will stand in a jar or tumbler) in a fairly warm place, and get time to examine them occasionally in the next two or three days.

The pepsin is a digestive ferment found in mammal stomachs, and

the pancreatin is a digestive ferment produced in the pancreas. Similar ferments are found in smaller quantities in many plant tissues. Digestion, with proteins as with other foods, puts the food in a soluble form that is readily taken up (assimilated) by the plant or animal tissue that uses it.

TEACHING NOTE.—If the fibrin is obtained dry from a drug store, it should be soaked up in water before using. Pepsin and pancreatin are also obtainable from drug stores. In many localities it will be impossible to obtain the fresh pineapple except in the spring season, and the demonstration of the digestive ferment in this fruit will have to be omitted.

Physiology
One laboratory period
Kinsey BIOLOGY, pp. 129–138

FOOD ELEMENTS IN MILK

Object.—To determine the food elements, and the approximate proportions of each, in cow's milk.

Materials.—For each student: Two test-tubes, one-half full of milk. A medicine dropper. A glass funnel. A piece of filter paper. A rule.

For the Class: Test-tube racks and extra test-tubes. Double-boiler from the kitchen. Two or more evaporating dishes. Two or more clay crucibles. Two ring stands, each with a clamp, a ring, and a gauze. A Bunsen burner (or alcohol lamp). Acetic acid.

Procedure.—The teacher will have put enough whole milk in each test-tube to make it one-half full. The test-tubes have stood undisturbed in a cool place overnight.

Measure the fat (cream) in a test-tube, roughly determining by means of the rule what proportion of the milk is made up of this food element. Remove the cream with the medicine dropper.

To the remainder of the milk (now called skimmed milk) add acetic acid drop by drop to precipitate the protein in the form of solid curds. Gently shake the tube as the acid is added, and add until no more curds will form. Fold a disk of filter-paper into quarters (a quarter-pie in shape) and place in a funnel. Through this strain out the curds, catching the liquid remainder of the milk (now called whey) in the second test-tube. The difference (measured with the rule) between the amount of skimmed milk and of the whey will indicate, roughly, the proportion of protein (curds) in the milk.

The teacher will collect several or all of the test-tubes of whey and evaporate it to dryness on the water-bath. The solid remainder is chiefly a carbohydrate (milk sugar).

The milk sugar still contains some mineral. The teacher will place the milk sugar in a crucible and heat it until it burns and until nothing more will burn. Or the teacher may place the milk sugar on a piece of clean filter-paper, place it on the gauze on the ring stand, and set fire to the filter-paper. In either case, the remainder will, roughly, represent the amount of mineral present in the milk.

Fill out a table similar to the following:

	Amount (inches or mm.)	Proportion of whole milk
Whole milk		100%
Fat (cream)		
Skimmed milk		(omit)
Whey		(omit)
Protein (curd)		
Milk sugar		
Mineral		

This method of analyzing milk is nearly enough exact to give us a good idea of the problem. Be prepared to describe the order in which you would do the things necessary to analyze milk.

Questions.—Name the four food elements in milk.

Which of the foods in milk are the most important? Why so?

What vitamins are in milk? Why did we fail to find them in this rough analysis?

What do we mean by saying that "Milk is one of our most nearly perfect foods"?

Physiology
One field period
Kinsey BIOLOGY, pp. 129–138

MARKET FOODS

Object.—To observe the number, quantity, and methods of handling foods in our markets.

Materials.—Paper and pencil.

Procedure.—Visit one or more (four if possible) modern food markets, perhaps including a general grocery store, a "chain" store, a meat shop, and an open fruit and vegetable market. In larger cities, each of these may merit a special trip. Previous arrangements should have been made with the proprietor of each place to allow this investigation at some convenient time, and perhaps to furnish one or more guides for the trip.

In each store or market, the class will divide into several small groups each to investigate an assigned part of the stock. List and make notes on each *kind* of food, filling in a table similar to the following. Do not take time to list the several brands of each kind of food.

Avoid damaging the store-keeper's stock. Work as far as possible without touching the stock. Do not interfere with the regular customers in the store.

Kind of food	Quantity in stock (*small, medium, large*)	Method of marketing (*fresh, dry, in cans, bottles, packages, etc.*)	Class of food (*chiefly sugar, starch, fat, etc.*)

Questions.—In which class of foods is the greatest *variety* of kinds available in our markets?

Which classes of foods are kept in the largest stocks? Why?

Which classes of foods are most easily preserved by modern methods?

Which classes of foods are being handled under the best sanitary conditions? The poorest? Why?

Are the commonest foods those most rich in vitamins? Why is this so?

What changes seem desirable in marketing conditions? Will the shopkeeper or buying public have to make these changes? Discuss why this is so.

Physiology
One or more laboratory periods
Kinsey BIOLOGY, pp. 129–138; 150–151

MENUS

Object.—To prepare menus for two days of balanced meals.

Materials.—None.

Procedure.—Using your knowledge of the four groups of foods and of vitamins (see especially pp. 129–138 of the Kinsey Biology), prepare a set of menus for the three meals of one (or more) days in mid-winter, and another set of menus for a day in mid-summer. Keep the following directions in mind:

Each day should include fair proportions of carbohydrates, fats, proteins, and minerals.

Each day should include variety enough to make the meals attractive, but for most people only one meal a day need be heavy.

Each day should include variety enough to include the vitamins, especially the ones obtainable in fresh fruits and vegetables.

Don't forget that minerals are obtainable from fruits and vegetables and cooked greens.

Some coarse foods in the diet are an aid to the digestive processes.

Toward the end of the period, let the class take at least half an hour to criticize the menus.

Physiology
One field period
Kinsey BIOLOGY, pp. 129–138

COMMERCIAL SOURCES OF FOODS

Object.—To observe the ways in which foods are prepared commercially.

Materials.—Pencil and paper.

Procedure.—Make a trip to a nearby garden, farm, market, or commercial establishment handling fresh foods. In most cases it will be desirable to have made arrangements with the owner or some other official to secure permission and perhaps a guide. Any of the following, among many others, would make profitable places to visit.

A large farm
Chicken farm
Fruit farm
Dairy
Truck garden
Creamery
Canning factory
Fruit-packing establishment
Slaughter house
City market
Milling plant

Let each student make notes from which to prepare a brief report that will record at least the following:

General description of place or establishment.
Chief foods produced.
Sources of materials (if a commercial establishment).
Special methods of preparing foods for use.
Chief problems in preserving foods until they reach the consumer.
The distances to which these foods are distributed over the country
Commercial importance of such foods.

Physiology
One laboratory period
Kinsey BIOLOGY, pp. 139–146; 153–155

VERTEBRATE RESPIRATION

Object.—To observe the way in which breathing is accomplished in man.

Materials.—A four-foot tape (or string and rule).

For the class: One or more watches. If possible, a living frog or toad in a jar, and a living fish.

Procedure.—**A.** Observation of breathing. Try to breathe as normally as possible while noting the way in which it is accomplished.

Are you breathing through your nose or mouth? See if it is as easy to breathe through the nose alone. Through the mouth alone. What are the advantages or disadvantages of each method of breathing? Do other vertebrates (dog, cat, horse, cow, etc.) breathe through the mouth or nostrils or both?

How do people breathe when they snore? Try making a similar sound. Can you tell where it is produced? Can you make it with the mouth closed? With the nostrils closed?

Note the chest movements that accompany respiration. Does the chest expand when the air is taken in or when it is breathed out?

With a tape (or string) measure the chest (putting the tape under the armpits) when it is expanded and when it is contracted as normally as you can do it. Repeat the measurements five times. Determine the average amount of expansion.

Measure the expansion of the waist-line during normal respiration. Is this as much as it should be? Discuss.

Now stand up and measure the chest expansion at five of the deepest breaths you can take. Determine the average expansion.

Does the air enter the lungs as a result of the chest expansion, or does the chest expand as a result of the intake of air? Try expanding the chest while both mouth and nostrils are closed.

What is accomplished by an occasional long breath? By yawning? Try taking in an additional amount of air *after* you have taken in the normal amount of air. Try breathing out an additional amount of air

after you have given out the normal amount. How then does the normal amount of air used in respiration compare with the amount that is in the lungs at any given time? Does this help explain why babies can hold their breath without smothering to death?

Can you figure out why we sigh when we have sad thoughts? Analyze this carefully!

B. Demonstration. The teacher may exhibit a living frog or toad in a jar. If so, watch any movements of its body that may show that it is respiring. How is the frog's respiration different from your own? Why does a frog breath that way? Recall that in man the normally dome-shaped diaphragm (see figure 73 of the Kinsey Biology) may be stretched flatter and the chest cavity consequently enlarged, aiding in the intake of air; when the diaphragm is released it becomes dome-shaped again and the chest cavity becomes smaller, thereby helping force the air out. Compare this with what happens in the frog or toad (and be careful of your morphology!).

C. Demonstration. If a live fish can be obtained in a small aquarium, take a little carmine (dissolved in water) in a medicine dropper, gently and slowly put the medicine dropper under water so its tip is near the fish's mouth, and gently squeeze out a few drops of carmine into the water where the fish is likely to suck it in. Let the class watch the gills of the animal and figure out the course of the water that entered the fish's mouth—and the relation of this to respiration.

D. Rate of respiration.—While keeping your respiration as normal as possible, count its rate for five minutes. Take the average per minute and keep a copy of the record made by the whole class.

Now exercise vigorously, either taking calisthenics or running around the school building (as the teacher may direct). Come back quietly and *immediately* take the rate of your respiration, counting each minute *separately* for the next five minutes. What does this show about the rate of respiration in relation to the rate of metabolism?

What, after all, is being accomplished in your body by this process of respiration?

Record your observations in tables similar to the following:

Expansion		
Normal for chest	Extreme for chest	Normal for waist
Averages.....		

Rate of my respiration	
Normal per minute	After exercise
Averages.....	

Physiology
One laboratory period
Kinsey BIOLOGY, pp. 135–136, 75, 520

CIRCULATION OF BLOOD

Object.—To observe or prove the circulation of the blood in the earthworm, amphibian, and human.

Materials.—For the class: Several live earthworms. Several small, live tadpoles. A watch with a second hand. A cloth or narrow bandage. Two or more demonstration microscopes with microscope slides and cover-glasses.

Procedure.—**A.** Place two or three fingers of your right hand on the pulse in your left wrist while you hold your wrist in your lap. Start counting to yourself when the teacher says "ready," start counting over again when the teacher says "go," and count the pulse rate for two minutes (timed by the teacher or by each student if enough watches are available).

Similarly count the pulse rate for two minutes in the region of the temple slightly above and well in front of your ear.

Similarly count the pulsations of your heart, as you may feel them about the middle of your chest, a little to the left of the breast bone.

Do you find any relation between the pulse rates at the wrist, temple, and heart? What does this indicate?

B. Now take the pulse rate at your wrist while another student takes the rate at your temple at the same time. Each of you should count out loud, but so softly that you do not interfere while still able to hear each other. Do you find the pulses at the two places are timed exactly together? Compare with results of others in the class. What does this show?

C. Cross the legs so one knee rests directly over and on the other. Let the upper foot hang freely. Count the rate per minute of the movement of the toe? What does this show about the circulation of the blood?

D. Note the blue veins lying close to the skin on the back of the hand. Can you detect any pulsation? In which direction?

Hold the hand downward and shake gently for a full minute or two. Note the result on the hand.

Hold the hand above the head for a full minute or two. Note the result.

Gently press a vein on the back of the hand, rubbing it tightly toward

the finger tips. Note results, especially at one of the V-shaped forks of the vein. What does this show about the circulation in the veins?

Wrap a string or bandage tightly around a finger about an inch from the end. Explain the result.

E. Be prepared to answer the following:

What do you know about the clotting of blood?

Explain the effects of vigorous rubbing, of a hot bath, and of a cold bath on the circulation.

Which animals have red blood?

F. Wash a live earthworm and carefully examine the circulation of the blood in the dorsal blood vessel which is visible directly through the skin of the worm.

G. While the class is at work on the above problems, let the students take turns at the microscopes. Wrap a small tadpole in a strip of wet cloth, allowing the tip of the animal's tail to project. Place on a piece of glass (microscope slide) with a thin cover glass on the tip of the tail. Examine this part of the tail under a lens of moderate magnification. Can you explain what you see? This observation was first made in 1677, ten years after William Harvey's death. What is significant in this?

Write a very brief description of the course of the blood in the human body, basing your statement on your own observations as far as possible.

Physiology *or* Morphology
One laboratory period
Kinsey BIOLOGY, pp. 139–141, 83–85

GRASSHOPPER RESPIRATION

Object.—To determine the course of the air in the respiratory organs of a grasshopper.

Materials.—Two live grasshoppers (or crickets, katydids, etc.). Two small vials. Cotton. A paint brush. Black ink.

Procedure.—Review the structure of the insect respiratory system, recalling the breathing pores located on the sides for most of the length of the body, and the fine, branching air tubes that lead directly to every part of the body.

Hold the live grasshoppers by their hind legs so they cannot pull away. Blacken the eyes of all the grasshoppers with a good coat of ink. This will not hurt them, and will cause them to quiet down for the rest of the experiment.

Carefully watch an undisturbed grasshopper. Can you see any body movements that might be connected with respiration? Describe carefully what you see.

Hold a live grasshopper with its abdomen in a small vial *full* of water, leaving the insect's head and thorax out of the vial. With a bit of cotton, plug the creature tightly in the mouth of the vial and, still holding the insect in place, turn the vial upside down. Note results for five minutes. Does the insect remain "well and happy"?

Now place the entire grasshopper under water and note results. Note the rate of respiration, the place from which any escaping gases may come and the general condition of the grasshopper. If the insect becomes limp or paralyzed, remove it from the vial and watch results carefully for some time.

Repeat either of the above experiments if your results are not conclusive.

From this, decide: (1) Whether the air enters the breathing pores on

both abdomen and thorax and comes out of the same pores; or (2) whether the air enters only certain breathing pores, circulates through the air tubes inside the body, and escapes by other breathing pores.

Write a brief description of your methods and your results.

TEACHING NOTE.—Hold each student responsible for bringing 3 or 4 live grasshoppers for this period; or, if the region is suitable, make a brief collecting trip at the beginning of the hour. City schools may have to depend on live material from the biological supply houses.

Physiology
One or more laboratory periods
Kinsey BIOLOGY, pp. 139–145

PRODUCTS OF ANIMAL RESPIRATION

Object.—To discover the products of respiration in an animal (man).

Materials.—For each carbon dioxide generator used: Three or more bottles, one with a cork with a bent glass (or partly rubber) tube. A square of glass. Bits of marble or limestone (or baking soda). Weak hydrochloric acid. A square of glass larger than the mouth of a bottle.

For each student: Two empty bottles. Another bottle with a little limewater. A square of glass (larger than the mouth of the bottle). A short piece of candle. Matches. A shallow pan of water. A piece of glass tubing (or a soda-water "straw") with a bent end.

For the next exercise: Three tall bottles with corks. Bean or corn or other seeds. A two- or three-inch seedling of bean (or pea, corn, etc.). Two vials of limewater, each with a cork. A bit of cotton. A quart jar. Several live leaves from a bush or tree.

Procedure.—**A.** Tests for carbon dioxide. The teacher will make two or more carbon dioxide generators as follows: Place some broken bits of marble or limestone (this is chiefly calcium carbonate, $CaCO_3$) in a bottle with a cork through which a bent glass tube leads out. Some weak hydrochloric acid will be placed in the jar with the marble. The gas given off by the marble is carbon dioxide, CO_2, the same gas that forms the bubbles in soda water.

By means of the tube leading from the carbon dioxide generator, the gas may be conducted wherever desired. Let each student take a little limewater in a bottle and allow carbon dioxide to bubble through for a few minutes. Note the result, due to the formation of an insoluble calcium compound when the CO_2 combines with the soluble calcium.

Now let each student fill a bottle with water, place a square of glass on top, and invert the bottle into a shallow pan of water so the bottle will stand inverted but filled with water. Now conduct the CO_2 into this jar, letting the gas replace the water until you have a jar full of gas, prevented from escaping as long as its mouth is under water.

Light the piece of candle, and when it is burning well, insert it into the jar full of carbon dioxide. To do this, pull the jar out of the water, quickly insert the candle, and put the mouth of the jar under water again. Do not let any drops of water extinguish the flame. Note how the candle burns in the jar of carbon dioxide.

Try a lighted candle in a jar of ordinary air. It is evidently a property

of carbon dioxide that makes the candle flame behave as it does in the bottle of carbon dioxide.

These two tests—the limewater test and the flame test—will identify carbon dioxide.

B. Animal respiration. Now blow gently through a glass tube (or a straw) into some limewater.

By breathing in through your nose and out through your mouth, gently blow a bottle full of the gas given out in respiration. Collect this gas over a pan of water as before, or blow into the bottom of an upright jar. Test this gas with the flame test.

What is at least one of the gases (actually the only gas) given out in an animal's respiration?

C. Other products of respiration. Now breathe on a clean (preferably cool) piece of glass. Besides the gas discovered in part B, what is another product of respiration?

Also recall the increased rate of respiration that accompanies physical exercise. Now can you prove what are the three products of an animal's respiration?

For the Following Exercise

A. Stopper tightly an empty bottle. Stopper tightly a tall bottle that contains an inch or so of dry bean (or other) seeds. Stopper tightly another jar containing a similar layer of soaked seeds. Set the three bottles aside with your name on each.

B. Fill a small vial with limewater and find a cork to fit it. Bore a hole through the cork (with a scout knife, cork borer, or nail), and put a well-grown bean (or other) seedling through the hole so the roots are below and leaves above the cork. Plug cotton tightly about the seedling where it passes through the cork. Replace the cork in the vial so the roots are submerged in the limewater.

C. In a quart jar place an inch or two of clear water. Put a goodly number of live leaves in the jar so that the leaf stems may dip in the water and continue to live. Stand a small vial of limewater in the quart jar (do not let it spill into the clear water) and fasten the top on the jar. Set this jar *in the dark* until the next exercise.

See that your name is attached to all this material. At the next laboratory period we will test these preparations for carbon dioxide.

Teaching Note.—Limewater may be prepared by taking some unslaked or hydrated lime and dissolving it (as far as possible) in water. A teaspoonful of lime is enough for a gallon of water. Heat is generated in this process, so mix the lime and water in a shallow dish, a pyrex or earthern dish, or a metal pan. Let stand for a day to allow the extra lime to settle out of the water; or strain it through a filter-paper. Keep well stoppered (with vaseline on the stopper) until used.

Physiology
One laboratory period
Kinsey BIOLOGY, pp. 139–145
Requires preparation at previous exercise

A PRODUCT OF PLANT RESPIRATION

Object.—To discover one of the products of respiration in plants of several sorts.

Materials.—For each student. The materials prepared for this exercise during the previous hour (see previous exercise). A bit of a yeast cake. A bit of molding bread. Matches. Limewater.

Procedure.—**A.** Do Seeds Respire? Take the bottle which contains dry seeds, hold it sideways, carefully take the stopper out of it, and instantly put in a lighted match. Note results.

Now put a little limewater into the bottle, re-stopper it, and vigorously shake the limewater with the seeds. Note results.

Repeat the flame and limewater tests with the bottle of soaked seeds. How do the results compare with those from the dry seeds?

Try the flame test on the empty bottle that has been corked. Where did the carbon dioxide come from in the two bottles with the seeds?

B. Do Roots Respire? Note the condition of the limewater in which the roots of the seedling have been growing.

C. Do Leaves Respire? Note the condition of the limewater in the jar in which live leaves have been kept.

D. Do Yeasts Respire? Take a bit of commercial yeast cake and dissolve it thoroughly in warm water enough to cover the bottom of a small jar for a half inch or more. Stopper the jar tightly and set aside in a warm place. In another day or so get time to try the flame test on this jar, and then to shake some limewater into it.

E. Do Molds Respire? Take a square inch or so of molding bread, place it in a small jar with enough water to just cover the bottom and set aside in a warm place. In another day or so get time to try the limewater test for carbon dioxide.

Questions.—Are the products of plant respiration the same as those of animal respiration?

Why did we make tests on these plants for only one of the three products of respiration?

Why were we able to test the animal respiration directly, while we had to prepare material for the plant tests several days ahead?

In some cases we used both flame and limewater tests; in others the limewater test alone. Why?

Why did we keep the leaves in the dark before we tested for carbon dioxide?

TEACHING NOTE.—This exercise should follow the tests for CO_2 given in the previous exercise. Most of the materials for this exercise should have been prepared by the students two or three days before. In addition, see that moistened bread (kept moist) has been previously exposed until it now bears a good crop of mold.

Physiology
One laboratory period
Kinsey BIOLOGY, pp. 145–146, 75, 153–155

PULSE RATE

Object.—To determine the pulse rate of the average boy and girl, at rest and after exercise and at various ages.

Materials.—For the class: One or more watches with second hands.

Procedure.—Work in pairs, remaining seated during part A of this exercise.

A. Find the pulse in your partner's wrist. Place the second or third finger of your hand on this pulse and count (to yourself) as the second hand of the watch approaches a convenient starting point. Then begin counting again, and count continuously for two minutes. (Or let the teacher act as time-keeper.)

Now let your partner take your pulse rate.

Repeat until each student has made at least three observations of two minutes each. Total the count for each student, and divide by the total number of minutes.

Compare this average rate per minute with the lowest and highest rates you obtained in your observations.

Compare your averages with the averages for the whole class.

Compare the averages of all the boys with the averages for all the girls in the class.

Have the teacher make a list on the board of all the individual averages in the class, arranged in the order of the ages of the students. Is there any relation between age and pulse rate?

Take the pulse rate of a much younger child, if the teacher has arranged to have one visit the class.

Now take the teacher's pulse rate.

B. Take your partner's pulse rate for three two-minute periods while he is standing up.

C. Now do two minutes vigorous calisthenics, or (as the teacher may direct) go out-doors and run hard around the school building. Come back quietly and immediately take the pulse rates.

D. Write up your observations and then, five or ten minutes after returning from your exercise, take pulse rates again.

Record your results in tables similar to the following:

My Partner's Pulse Rate				
	Seated	Standing	After exercise	10 min. later
First 2 min..... Second 2 min..... Third 2 min..... Total 6 min.....				
Average per min..				

Pulse Rate of Whole Class							
	Girls	Boys	Age..	Age..	Age 12	Age 13	Age..
Lowest..... Highest.....							
Average....							

Questions.—Why did you count for two minutes instead of one, each time you made an observation?

How can you explain the differences in your several counts made while your partner was seated?

How many explanations might account for the differences in the pulse rates of the individuals in the class.

Can you see any reason for the differences in pulse rate at different ages?

What physiologic processes other than blood circulation were affected by your exercise? Can you explain what relations these other processes may have to blood circulation?

Genetics
One laboratory period
Kinsey BIOLOGY, pp. 164–169

THE 3 TO 1 RATIO IN CORN

Object.—To determine how nearly the 3 to 1 ratio holds in hybrid corn: and to determine how many observations are necessary to obtain an exact 3 to 1 ratio.

Materials.—An ear of hybrid (yellow and white, or red and white) corn, the result of mating pure dominant and pure recessive grandparents.

Procedure.—Mark with a pencil the bottom grain of one row of the hybrid corn as a starting point for your observations.

Record the colors of the first four grains of each row of the ear.

Record the colors of the grains in each row. Secure the ratio by dividing the number of colored grains by the number of white grains, carrying the result to one decimal place.

Total the results for the whole ear.

Total the results for the whole class.

Record your results in a table similar to the following:

Colors of Hybrid (F_2) Corn

Row	First 4 Grains			Entire Ear		
	Colored	White	Exact 3 to 1 ratio	Colored	White	Ratio
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
My totals.....						
Class totals.....						

Questions.—Do you get a 1 to 2 to 1 ratio (a 3 to 1 ratio) in this exercise? Why?

Which is the dominant color in this corn? How can you tell?

Does the ratio hold for small numbers of individuals?

Does the ratio always become more exact the larger the number of individuals considered? Compare your results with those of others in your class.

Then would you expect the 3 to 1 ratio to be most accurate in families of few individuals, in families of many individuals, or in counts of large numbers of individuals representing many families?

Teaching Note.—The necessary corn material may be grown, but it is inexpensively purchased from G. S. Carter, Clinton, Connecticut, and probably obtainable from other dealers. For high-school work secure corn that shows a simple 3 to 1 ratio (preferably of a color character), or at most a 9:3:3:1 ratio in which one pair of contrasting characters is for the color of the grains. If the grains are not removed, the ears may serve for several years.

Genetics
Two laboratory periods
Kinsey BIOLOGY, pp. 164–169

WHY IT IS A 3 TO 1 RATIO

Object.—To determine whether Mendel's 3 to 1 (1 to 2 to 1) ratio also applies to non-living things.

Materials.—Two coins. A box of 100 beans of one color, thoroughly mixed with 100 of another color (or white beans that have been touched with ink). A box of 100 beads of one color thoroughly mixed with 100 beads of another color. A box of 100 small slips of paper marked "B" and 100 similar slips marked "b".

Procedure.—Work in pairs.

A. Let the first student hold two coins loosely in his clasped hands, shaking them and dropping them on the table. The second student will record the positions in which the coins fall on the table, making a stroke in the correct column in the table below. Let each student make 50 throws.

B. Mix thoroughly the beans of two colors. One student, blindfolded, takes 2 beans at a time from the box, while the second student records results. Let the students change places after 50 observations.

C. Repeat as with the beans, this time using colored beads.

D. Repeat as with the beans, this time using slips of paper marked B and b.

Record your results in a table similar to the following:

	Record	Totals	Expected ratio
COINS:			
2 heads			25
1 head, 1 tail			50
2 tails			25
BEANS:			
Both colored			25
1 white, 1 colored			50
Both white			25
BEADS:			
Both colored			
1 white, 1 colored			
Both white			
PAPERS:			
Both B			
One B, one b			
Both b			

Questions.—When hybrid (Bb) parents are mated, *why* are there twice as many offspring with (Bb) genes as with either (BB) or (bb) genes?

Is it some mysterious quality of living things that causes the ratio to be 1 to 2 to 1? Or is it the result of "chance"?

Were your results similar with the dead things (coins, beads, paper) and living things (beans)?

In any case, did you secure an exact 1 to 2 to 1 (or 25 to 50 to 25) ratio?

Why did you get a 3 to 1 ratio in the corn, and only 1 to 2 to 1 ratios in the present exercises?

Genetics
One field period
Kinsey BIOLOGY, pp. 172–178

GOOD BREEDS AND BAD BREEDS

Object.—To observe the extent to which the principles of heredity are applied on our farms.

Materials.—Pencil and paper.

Procedure.—**A.** Make the trip to the city market, or (in rural regions) to several farms, including large and small farms and progressive and backward farms.

Make notes on the best variety of each kind of animal (horse, cow, hog, chicken, etc.) seen in the market or on each farm.

Decide which is the best variety of each kind of animal seen on the trip.

Pay especial attention to the number of varieties of each animal on each farm, or in each shipment in the market. Has each farmer selected a single variety (a pure breed) of each animal, or does he take anything (mongrel or scrub) that comes along? In either case, why does he do it that way? Which method has given the farmer the better results?

B. If the above is impossible, make the trip to a greenhouse or to a large garden.

Does the grower have a large or small number of varieties of each kind of flower? Try to find out whether this is because he has rejected other varieties, or because he didn't know of other varieties, or because no other varieties are obtainable?

If the grower has rejected other varieties, were they better (and perhaps more expensive) or poorer varieties? If you can talk to the grower, ask him whether he considers the quality of his seed, bulbs, and stock (its heredity), more important or less important than the way in which they are grown (its environment).

Write a *brief* account of the trip, mentioning what you considered the most important things learned.

Teaching Note.—This trip, simple as it is, always proves very impressive to beginning students. It is possible in any rural community or in any city with a large market or freight yard where large numbers of crated hens or other poultry may be observed. Suburban schools will more often have to depend on a greenhouse or large garden.

Genetics
One laboratory period
Kinsey BIOLOGY, pp. 189–192

INDIVIDUAL VARIATION IN BEANS

Object.—To determine how much variation there is in the lengths of 150 lima beans.

Materials.—About 150 dried lima beans (a scant cup) representing all sizes obtainable. A rule. A piece of cross-section paper.

Procedure.—Arrange the lima beans flat on the table, placing them in vertical rows according to their longest dimension. For instance, in one row place all the beans over $^{11}/_{16}$ inch but under $^{12}/_{16}$ inch in length, in another row place those over $^{12}/_{16}$ inch but under $^{13}/_{16}$ inch, etc., paying regard to every difference of $^{1}/_{16}$ inch (or 1.0 mm.) in length. Put the rows of smallest beans to the left, the rows of largest beans to the right, and the other rows in careful order between.

Compare your final arrangement with the results of the others in the class.

Record your observations in the cross-lined squares of a piece of cross-section paper, shading in one square for each bean, so your final diagram exactly represents the way in which your beans were arranged on the table.

Questions.—How different in length were the most extremely different beans?

Were there more beans that were alike or beans that were unlike? How can you explain this from what you know of heredity?

Which beans would be most likely to give rise to new species: the extreme sorts, or the average sorts? Why?

Can you explain the resemblance of your arrangement to that of the epidemic organisms shown on page 298 of the Kinsey Biology?

Teaching Note.—Buy these beans from several places and mix them thoroughly, in order to avoid a selected group of specimens.

Genetics
One laboratory period
Kinsey BIOLOGY, pp. 189–192

OTHER CASES OF VARIATION

Object.—To observe the individual variation in (one of the following).....

Materials.—As indicated below. Also a piece of cross-section paper.

Procedure.—Unless the teacher has already provided the material, go out and secure 100 specimens of *one* of the following (or make all your observations right in the field):

Leaves of any kind of tree in which the side veins are numerous and evident (beech, chestnut, elm, cherry, etc.). Record how many have 8 veins, how many 9 veins, etc.

Leaves of some bush or tree with pinnately compound leaves (sumac, walnut, butternut, elder, etc.). Record how many have 9 leaflets, how many 10 leaflets, etc.

Heads of a composite flower with numerous ray ("petal") flowers (daisy, sunflower, sneezewood, coriopsis, etc.). Record how many have 6 rays, how many 7 rays, etc.

Secure records of the heights of adult men or women. Record how many are 5 feet 6 inches, how many 5 feet 7 inches, etc.

Leaves (each with its numerous leaflets) of blackberry. Record how many have 3 leaflets, how many have 4 leaflets, how many 5, etc.

Grass blades (that have not been cut). Record lengths by half inches, totaling number for each length.

Preserved earthworms (50 will do). Record the number of segments for each, and record how many have each segment number.

Dead grasshoppers (50 will do). Record the number of segments in each antenna, and the total number of antennæ with each segment number.

Specimens of almost any common object with numerous parts that can be counted or lengths that can be measured.

Instead of arranging the actual specimens as we did in the previous exercise, record your information in a table. Then on the ruled squares of a piece of cross-section paper, make a graph similar to that in the previous exercise (or like the figure on page 298 of the Kinsey Biology).

Questions.—Compare all of the diagrams made in the class. Are they all similar? Did it matter whether it was a plant or an animal studied, or one species or another?

Were there any of the diagrams that were unusual in shape? Can you see any reasons for this?

Which does your exercise prove: That individuals of a species differ, or that individuals of a species are more alike than different?

TEACHING NOTE.—Where time and conditions allow, it is better for each student to gather his own material.

Genetics
One field or laboratory period
Kinsey BIOLOGY, pp. 187–197

NEW BREEDS

Object.—To observe the number and character of recently introduced breeds of domesticated plants and animals.

Materials.—Pencil and paper.

Procedure.—The class will make *one* of the following studies, taking notes from which a brief written report may be prepared.

A. Field trip. Visit a large greenhouse, a nursery, or a large garden. Make a rough estimate of the number of different kinds of plants being grown.

Make an accurate count of the number of varieties of some one kind (or genus) of plant (*e.g.*, iris, lilies, tulips, narcissi, daffodils, asters, chrysanthemums, roses, peonies, gladiolas, columbines, lilacs, grapes, pears, peaches, plums, apples, cherries, pines, spruces, junipers (cedars).

Perhaps one of the gardeners can tell you how many of these varieties have come into existence in the last 50 years. Perhaps of some that are much newer than that! He may know something of the way in which some of these varieties originated.

B. Laboratory exercise. Study a large, illustrated catalog of nursery plants (flowers, shrubs, trees, fruits, etc.). Make a rough estimate of the number of different kinds of plants grown by the nursery. Make an accurate count of the number of varieties offered in each of 6 kinds (or genera) of plants (see the list in part A). Look over carefully some of the descriptions in the catalog for information on the history of the newer varieties (this will indicate only a small proportion of those that have originated in recent years).

C. Field trip.—Visit several of the largest and most progressive farms, dairies, or orchards in the region. You will need as a guide the county agent, or some other graduate of an agricultural school. Keep a record of the number of varieties of each kind of farm crop that you observe, and your guide may be able to give you some idea of how many of these have come into existence within the past 50 years, and perhaps tell you some details about the origins of some of the newer varieties. Take pains to discover, if you can, in what ways the newer varieties are improvements on the older.

D. Field trip.—Visit a poultry show, dog show, State or County Fair, or other large exhibition of domesticated animals. Estimate the number of different kinds of animals exhibited, and make an accurate count of the number of varieties of one of the more important animals. Secure all the information you can about the origins of some of the newer varieties and discover just why the breeders were interested in securing his new sort.

Teaching Note.—It may be necessary to postpone this trip until some later season. If one of the field trips is not feasible, use part B as a laboratory exercise. Illustrated nursery catalogs may be had of any nurseryman in quantity enough for a whole class. For addresses, see the important advertisements in a reputable garden magazine (avoiding the advertisements in cheap farm or garden journals).

Genetics
One laboratory period
Kinsey BIOLOGY, pp. 199–200; 204–209

ADAPTATIONS IN INSECT LEGS

Object.—To observe the ways in which insect legs vary in structure as adaptations fitting the insect for its existence.

Materials.—Mounted (dry and pinned) specimens representing a number of insects.

Procedure.—With the naked eye, examine the legs of some insect that uses its legs for walking: a wasp (or hornet), an ant, or a ground beetle is such an insect. Each leg consists of the following parts (beginning where it is attached to the thorax): coxa, trochanter, femur (the heaviest segment), tibia (usually the most slender segment), and the tarsus (made up of several small segments). Be sure you can recognize at least the femur and tibia. Compare the three pairs of legs in this walking insect, noting especially any differences that may exist in the femora and in the tibiæ of the three pairs.

Now examine the legs of each of the other kinds of insects, in each case considering:

The chief differences from a walking leg.

Comparisons of femora in the three pairs of legs.

Comparisons of tibiæ in the three pairs of legs.

Any special leg structures that might help the insect secure its food, attack its enemies, get over the ground, etc.

Your guess as to the special use the insect makes of its legs (*i.e.*, for what it seems adapted).

Record your data in a table similar to the following:

Insect	Comparison 3 pairs femora	Comparison 3 pairs tibiæ	Special structures	For what adapted

The walking leg seems to be the primitive type of leg from which the others have evolved as adaptations.

Check your guesses as to the functions of these legs.

Teaching Note.—For the present exercise use any mounted insects that the school may own. The material collected earlier in the year by the students will probably suffice. Common insects will do, but the following are some of the families that have legs showing distinct adaptations. Each student needs only a few insects at a time, and by circulating the available material, one representative collection will suffice for the whole class.

Dragon flies
Roaches
Walking sticks
Grasshoppers
Crickets
Mole crickets
Termites (white ants)
Any fly
Ground beetle
Leaf beetle
Diving beetle
Lady beetle
Stag beetle
Cicadas
Plant lice
Giant water bugs
Back swimmers
Water striders
Water boatman
Any butterfly or moth
Water penny
Dung beetle
Ant
Wasp or hornet
Honey bee
Bumble bee

Genetics
One laboratory period
Kinsey BIOLOGY, pp. 204–209

PROTECTIVE COLORS OF ANIMALS

Object.—To determine why most birds and mammals are lighter beneath and darker above.

Materials.—Four small paper bags (of one size for each student, various sizes in the class). String. Old newspapers. Dark-colored ink. A paint brush.

Procedure.—Make 4 "animals" by stuffing 4 paper bags full of torn and crumpled newspaper, tying the bags at the top.

Leave one bag natural in color.

Paint the entire surface of one bag with a dark-colored ink that has been diluted with water.

Considering the other two bags as "animals," with the tied ends as tails, paint one half of each animal, leaving the other half light in color.

Place the four animals in a row (not too closely together) at one end of a long corridor, or out-of-doors in a good-sized open space. Place one of the half-dark animals with the dark surface down, and the other with the dark surface uppermost. Walk away from these animals, and see which is most easily noticed at various distances. At each distance record the visibility of each animal as conspicuous, inconspicuous, or hidden.

The following form of table will prove convenient for your observations:

Visibility of Animals				
Distance	Entirely dark	Entirely light	Dark below	Dark above
At 10 feet..... At 50 feet..... At 100 feet.... At 200 feet....				

Questions.—Before working this exercise, which of the four animals would you have expected to be most conspicuous?

Was the same animal most conspicuous both when you were close and when you were at a distance?

Can you explain *why* the one animal showed up less prominently than any of the others?

Do you know how this principle was used in painting battleships, hiding machine-gun nests, etc., in the World War? Look up Abbott Thayer and his camouflage work.

Do you know any birds or mammals that are darker beneath and lighter above? What do you know of the habits of these that would explain their unusual coloring?

Can you explain what we mean by calling this protective coloring of a bird or mammal an adaptation?

What reason can you give for the fact that few insects are lighter beneath and darker above?

Genetics
One field contest
Kinsey BIOLOGY, pp. 204–209

SOME PLANT ADAPTATIONS

Object.—To observe some common plant adaptations, by means of which the plant is protected, its growth furthered, its seeds distributed, etc.

Materials.—Paper and pencil.

Procedure.—Make the trip to any place where a variety of plants may be found.

Let each student try to be the first to show the class an adaptation among plant structures. Search for some of the following:

Structures which protect plants from insects, cattle, winds, etc.
Structures which protect seeds or aid in their dispersal.
Structures by which the plant secures its food.
Structures and habits which allow plants to survive the winter.

Credit 2 points to each student who is first to discover and point out a given plant adaptation.

Deduct 2 credits each time a student shows a structure which he cannot prove to be an adaptation.

List (by brief titles) the adaptations shown on the trip.

Questions.—How common are adaptations among plant structures?
Why did you not know this before?
Do you suppose they are as common among animals?

TEACHING NOTE.—The weed-grown lot in the city, the suburban field or roadside and more open country are all possible places for this trip. The trip is profitable at any season of the year, even in the winter, when the dead weed stems, remnants of seeds, winter rosettes, leafless trees or narrow-leaved conifers, etc., furnish clear-cut cases of adaptations.

Ecology
One field period
Kinsey BIOLOGY, pp. 226–235

ECOLOGIC RELATIONS

Object.—To observe as many cases of ecologic relations as we can discover.

Materials.—A pencil and paper.

Procedure.—Let us try to see more than single plants and animals in this world. Let us go out-of-doors and see how organisms affect each other in their various types of ecologic relations.

We can make the trip any place in town, or open country, in the city park or weed patch—even in the city streets where people exist in intimate ecologic relations with each other.

A. Of how many of the following types of relations can we discover good instances *on this trip?*

Inorganic	Social	Parasitic
Organic	Symbiotic	Scavenger
Threptic	Predatory	Economic

B. Let us discuss each case as we discover it. Name the kind of relation represented. Name as many other things as we can actually observe affecting this particular organism.

There are ecologic relations of some sort to be seen everywhere among living plants and animals:

Plants dependent on food in the soil;
Trees eaten by insects;
Dead wood with bacteria of decay;
Insects gathering in sunny spots;
Other insects hiding in the dark under a board or a stone.
Birds hunting food.
Flowers visited by insects.
Lichens borne on tree trunks.
Grass killed by the passing of many feet—and an endless list of other relationships that are the subject of ecology.

Let each member in the class keep a list of every ecologic relationship that we recognize on this trip.

Ecology
Two half periods of demonstration
Kinsey BIOLOGY, pp. 228–229, 1–3

EFFECTS OF FREEZING TEMPERATURES

Object.—To determine whether cold-blooded animals may freeze without dying.

Materials.—One or more live, cold-blooded animals. Small cardboard boxes. A wooden box of sawdust.

Procedure.—The teacher will place each cold-blooded animal alive in a small cardboard or wooden box (or in a can with holes). These boxes will be embedded in a wooden box large enough to allow at least an inch of sawdust between each animal and the outside of the box. The whole will be placed for 6 hours in an ice-chest in which the temperature is not below 45° F. (the average household ice-chest is not too cold). Then it will be kept from 12 to 24 hours in the coldest ice-chest available.

In thawing out the animals, great care will be taken to raise the temperature gradually. Death in these animals is more often due to sudden thawing than to extreme freezing. First put the box of material in a cooler chest for at least 6 hours, then in a cold place out-of-doors for a few hours. Finally open it in a warm room before the class.

Write a brief report of this experiment.

Teaching Note.—Frogs, toads, turtles, snakes, native fish (in a cup of water), and some insects (especially such larvæ as caterpillars and beetle grubs) are good materials for this experiment. Use as many kinds as are available.

Some family ice-chest, or the school cafeteria ice-box, or the cold-storage room of a local butcher will perhaps be available for this demonstration. An improvised ice-chest may be made out of a packing box with a couple of inches of sawdust surrounding several cakes of ice in the center of which the experimental material is placed.

Ecology
One laboratory period
Kinsey BIOLOGY, pp. 264–266

PLANTS AS SOIL COVERS

Object.—To observe the way in which plants prevent soil erosion.

Materials.—For two students: Two glass funnels. Two pieces of filter-paper (or absorbent cotton). A small quantity of garden soil. Decaying leaves, etc. (obtained from a rich garden or woods floor). Two small jars. Perfectly dry peat moss (*Spaghnum*, obtainable from florists). A pan of water. A rule. A piece of sod. Two deep dishes.

Procedure.—**A**. Place filter-papers in the bottoms of two glass funnels (or plug loosely with absorbent cotton). Fill one with earth to within an inch of the top. Put an inch less earth in the other, and place on it an inch of a *mulch* consisting of decaying leaves and other such material. Place the funnels upright in test-tubes or in small jars *of equal size.*

Pour a cup of water on each soil sample, note the way in which the mulch behaves, and note the amount of water that has gone through each sample at the end of 2 minutes, 5 minutes, 10 minutes.

B. Take a sample of perfectly dry peat moss, press it down tightly until you have a solid cupfull. Take the moss out of the cup, soak it in a pan of water, lift it out, and (without squeezing it) let the surplus water drain off. Now squeeze the moss, catching this water in a cup as you press out all you can. Determine the relative amounts of moss and of water there might be on a wet forest floor.

C. Place two samples of soil in open-topped receptacles (funnels, pans, dishes, etc.). On one place a piece of sod. Make both samples moderately wet. Now turn a current of water onto a single spot in each sample in turn (place the samples under a faucet, or pour water onto them from some height). Compare the effects of rainfall and stream-flow on bare ground and on ground with a plant cover.

Figure out your own form for recording your results.

Teaching Note.—Obtain a supply of decaying leaves and other organic matter from a gardener's compost heap or from a rich woods. Peat moss (*Spaghnum*) may be found in some nearby forest or swamp, but is always obtainable from local florists or nurserymen. The sod necessary for part C of this exercise is usually obtainable locally; for winter classes it should be cut and brought in before the ground is frozen. The sod may be used even when dead, a few feet of closely clipped, thin sod sufficing for a whole class.

Ecology
One laboratory period
Kinsey BIOLOGY, pp. 261–262

COMPOSITION OF SOILS

Object.—To determine the composition of a sandy soil, a field or garden soil, and a rich woods soil.

Materials.—*Dry* samples of the three soils. Three quart jars. Three tumblers (or pint jars). A glass tube. A funnel. A graduate (or a test-tube and a rule).

Procedure.—Take equal quantities (about half a cup) of each of the soils and slowly add water to each while working it up into a paste. Place each paste in a quart fruit jar, nearly fill the jar with water, shake for some time until the soil is thoroughly mixed in the water, and then allow the jar to stand until near the end of the period. By then the soil will have settled to the bottom.

Do the same with equal samples of the two other kinds of soil.

While waiting for the soils to settle, put a new, dry sample of soil into a tumbler or small jar. Use samples of the same size as in the first experiment. Shake the soil down in each tumbler, but do not pack it. Push a glass tube to the bottom of the soil and, using a funnel, pour a measured quantity of water down the tube so the soil fills up slowly from the bottom. Measure the water by pouring from a graduate or from a test-tube; in the latter case, measure the water in inches before you begin and after you stop pouring into each sample.

Pour in enough water to bring the water level even with the top of the soil in the jar. The water has replaced the air in the soil, and since you measured the water used, you know how much air there was in the soil. Repeat with the two other kinds of soil.

Now go back to the samples which were settling out of the water. The course material on the bottom is sand; the finer material above it is mostly clay; and the broken bits of more or less decayed plant material floating on top is the humus. Measure (with a rule) the amount of each material in each sample of soil.

Record your data in the following form:

	Inches of			
	Sand	Clay	Humus	Air
Sandy soil				
Field or garden soil				
Woods soil				

Questions.—Of what value to growing plants are each of the materials (sand, clay, humus, air) found in soil?

Why is there more humus in the woods soil? Is this the best soil for growing garden or farm crops? Why?

Ecology
One laboratory period
Kinsey BIOLOGY, pp. 262–263

WATER EVAPORATED FROM LEAVES

Object.—To determine how much water is evaporated from a single leaf and from a tree in a day.

Materials.—A vial with a stopper. Two or more freshly gathered leaves. Sealing wax. Vaseline. Two microscope cover glasses. A wire paper clip.

For the class: A cork borer.

Procedure.—**A**. Spread a thin coat of vaseline over both surfaces and the leaf stem, including the cut end of the stem, of one or more leaves. Place in a tightly corked jar with the cork sealed with vaseline.

Similarly place one or more uncoated leaves in a corked jar, this cork also sealed with vaseline.

Set both jars aside and get time to examine them within a day or so.

B. Lay two microscope cover glasses opposite each other on opposite sides of a leaf, fasten in position with a wire paper clip, seal the edges of both glasses with vaseline, put the stem of the leaf in water, and set aside. Get time within a day or two to examine this material. Which glass has the most moisture collected on its inner surface? Why?

C. Bore a hole (with a knife, cork borer, or nail) through a stopper that fits into a vial. Make the hole just large enough to admit the leaf stem (petiole) of a healthy leaf (or use a branch of leaves and a larger jar of water). Seal the leaf (or branch) air-tight in the stopper by means of sealing wax (or vaseline or melted paraffin well worked down around the leaf stem). Fill the vial with water and stopper so the leaf stem is in water. Make the stopper tight with sealing wax so any water lost from the vial may be credited to evaporation through the leaf. Note results at the end of the hour, and get time to look at this material a couple of days later. Then very carefully measure the amount of water it takes to fill the vial, find out what part of a quart was evaporated by your specimens, and figure out what part of a quart is evaporated by one leaf in a single day.

Meanwhile, estimate the number of leaves that may grow on a big tree by counting accurately the number of leaves on a branch of moderate size, multiplying by the number of times (as estimated) that branch is contained in a whole section of the tree, and multiplying by the number

of times that section is contained in the whole tree. Now multiply by the part of a quart evaporated by one leaf per day—and you will gain a very rough but nevertheless instructive idea of the amount evaporated by a whole tree in a day. Your results will be worth more if you use a single species of plant for both your experiment and your estimate.

Summing up, the data necessary in this last part of the exercise are:
Water evaporated from specimens in — days.....
Water evaporated by one leaf per day.....
Number of leaves estimated per large tree.....
Estimated amount water evaporated per day per tree.....

Questions.—What is the one main conclusion from these three experiments?

What causes a leaf to wither?

What effects on climatic conditions would you expect as the result of the evaporation from a forest of trees? Explain.

Teaching Note.—If this exercise is worked in the winter, the class will have to depend on leaves of potted plants or seedlings grown in the laboratory or obtained from a greenhouse. Then let the class use some of the following figures for the estimate: a large wild cherry had 3,000,000 leaves; a large oak had 400,000 leaves; a red maple of medium size had 60,000 leaves.

Ecology
One laboratory period
Kinsey BIOLOGY pp. 264–266

FORESTS AS WATER CONTROLS

Object.—To determine the relative amounts of water that may be absorbed and held by a sandy soil, a field or garden soil, and a forest soil.

Materials.—For two students: Samples of the three kinds of soil that have been thoroughly dried. Three pieces of filter-paper. Six glass funnels. Three small jars. A graduate (or test-tube and rule). Three pieces of ½-inch glass tubing (or test-tubes with broken ends). A pan of water.

Procedure.—Work in pairs.

A. Loosely fold three filter-papers and place them in three glass funnels (or plug the funnels loosely with cotton). Fill each of the funnels to within an inch of the top with one of the samples of soil, and stand in three small jars.

Using a graduate or test-tube (in the latter case measuring the water used as inches on the test-tube), slowly pour water over the woods soil in one of the funnels until it begins to run through. Catch the water in the jar under the funnel. Pour equal amounts of water into each of the other samples, and let drain into the jars beneath.

Measure the amounts of water in each jar at the end of ten minutes, and again near the end of the period. This amount, subtracted from the amount used, will show how much water was absorbed by each soil in the given time.

B. While waiting for results in part A, take additional samples of the three soils in three funnels (or test-tubes with small holes in the lower ends). Pour equal amounts of water onto each sample, but use a small quantity this time, enough to wet the top inch or so of soil but not enough to run through. Observe the depths to which the water has spread in each soil at the end of 5 minutes, 10 minutes, 15 minutes, etc. Do you learn anything from your results in this part of the exercise that you did not learn in part A?

C. Nearly fill three lengths of glass tubing (about a half inch in diameter, or test-tubes with the ends broken out) with samples of the three soils. Stand upright with one end of each column of soil in a pan (jar or broad tumbler) of water. Record the height to which the water has risen in each tube at the end of 5 minutes, 10 minutes, 15 minutes, etc.

The following form of table may be convenient for recording your results:

	Amount of water absorbed		
	Sandy soil	Field or garden soil	Rich woods soil
Exercise A: 10 mins..... 1 hr. 10 min.....			
Exercise B: 5 min..... 10 min..... 15 min.....			
Exercise C: 5 min..... 10 min..... 15 min.....			

Questions.—When would conditions out-of-doors be most like those in part A of this exercise?

When most like those in part B?

When most like those in part C?

Can you explain why the one kind of soil was more valuable as an absorber and holder of water?

What are some practical applications of the knowledge gained in this experiment?

Teaching Note.—Results in this exercise are often obscured by the use of soils that are damp to begin with. The necessary quantities of the soils should have been stored in a dry place indoors for at least a month before they are needed. Otherwise it will be necessary to bake the soils in an oven or over a flame.

Ecology
One field period
Kinsey BIOLOGY, pp. 266–267

FOREST PRODUCTS

Object.—To observe some commercial uses of forest products.

Materials.—Pencil and paper.

Procedure.—Make the trip to an industrial establishment that depends chiefly upon forest products for its raw materials. One of the following (or some other place) may be within easy reach:

Lumber yard	Maple syrup camp
Saw mill	Tanning establishment
Furniture factory	Paper mill
Turpentine camp	Charcoal plant
Lumber camp	Paper box factory

If arrangements have been made beforehand with one of the officials of the company, permission to go through the plant and probably a guide may be furnished.

Let each student make notes necessary to write a brief report, including at least the following information:

Kinds of commercial products produced.
Places from which raw materials come.
Parts of trees used.
Methods of manufacture.
Size and importance of this industry in the country as a whole.

Ecology
One field period
Kinsey BIOLOGY, pp. 290–293, 412

FLY BREEDING PLACES

Object.—To discover the possible breeding places of house flies in a given area.

Materials.—Pencil and paper.

Procedure.—The class will be divided into groups of 4 or 5 students each. Each group will be assigned a limited area (4 city blocks, or 3 or 4 pieces of property or farms in more open country).

Each group will carefully explore the assigned territory, making a list of all the places in which house flies might be expected to breed. Watch for stables, open privies, sanitary conditions around new building operations, etc. O.K. such places only if you are satisfied they are properly cared for. Learn to be frank in such an investigation; the health of a community may depend on the honesty with which its citizens will consider such problems.

It will probably be impossible for you to discover conditions inside the dwellings in your area.

Each student should write a brief report of his survey with recommendations for improving the situation in his particular area. If breeding places are not found, let the report explain why.

TEACHING NOTE.—Unless the weather is too severe for the class out-of-doors, this trip is possible in the winter, although a larger number of temporary sources of fly infestation may be found in warmer weather.

Ecology *or* Genetics
Two laboratory periods
Kinsey BIOLOGY, pp. 301–313, 204–209, 499–503

BIRD ADAPTATIONS FOR FEEDING

Object.—To observe the special bill, foot, leg, and wing structures by which birds secure and handle their food, and which consequently make them of economic importance.

Materials.—For the class: A number of stuffed birds representing several different families (or large-sized pictures of such birds).

Procedure.—Examine the bill, legs, feet, and wings of each bird specimen (or picture) until you have studied all that are in the collection. In making this study you might note the following:

BILL: General shape, size, and strength; width compared with length; differences between upper and lower halves; tip; mouth structures like long hairs, etc.

LEGS AND FEET: General size and strength, especially length of legs, number and arrangement of toes, any special foot structures such as webs, masses of bristles, etc.; claws.

WINGS: Length, breadth, any peculiar shape.

From these structures, try to figure out the activities of each bird (continuous flight, short flights, ground collecting, fishing on or under the surface of the water, climbing tree trunks, etc).

Then from this, try to reason out the sort of habitat (on the ground, in open air, in tree tops, on tree trunks, in thickets, etc.) in which each kind of bird lives.

See if you can figure out the sort of food it probably finds to eat in such a place, and the sort of food it can capture with such a bill, foot, etc.

Prepare a table similar to the following for your report on this exercise.

Bird	Bill	Legs	Feet	Wings	Activity	Probable food
EXAMPLE: *Loon...*	*Large, broad*	*Short*	*Webbed*	*Short, very small*	*Swimming, little flight*	*Water animals*

Toward the end of the second period, the whole class will compare results and from what the various students know of the actual food of

birds, you may correct your guesses as to the probable food of the species you have studied.

Questions.— What does this show to be one of the reasons for the economic importance of birds?

From this exercise, can you give some explanation of the fact that birds are economically more valuable than most other organisms?

Again review and define what we mean by an adaptation.

Teaching Note.—The high-school biology department might profitably accumulate a collection of stuffed birds, bought from the taxidermists or accumulated from specimens found dead from accidents. On the other hand, this exercise is easily worked with colored bird plates such as are obtainable at slight expense from the National Audubon Society, New York City. Mount such plates on cardboard to preserve them from year to year. Birds figured in their natural habitats should be cut out and pasted on white backgrounds. Prepare at least twice as many plates as there are students in the class.

Birds especially useful for this exercise include representatives of any of the following (among other) families: loons, gulls and terns, ducks and geese, herons and bitterns, snipes and sandpipers, grouse and bobwhites (also domestic chickens), pigeons and doves, buzzards, hawks, owls, cuckoos, woodpeckers, nighthawks and whippoorwills, swifts, humming birds, flycatchers, crows and jays, blackbirds, sparrows, swallows, shrikes, vireos, wood warblers, thrashers, wrens, creepers, nuthatches, kinglets, robins, bluebirds and thrushes.

Ecology
One field or laboratory period
Kinsey BIOLOGY, pp. 329–341

PLANT GALLS

Object.—To observe the way in which the normal plant tissues are modified by gall fungi and gall insects.

Materials.—A piece of paper. Bits of iron (filings). A couple of vials or bottles. A paper bag. If possible, a jack knife.

Procedure.—**A.** Make the trip to the fields and scrub growth and older woodlands. Let the class see how many distinctly different kinds of galls it can find in the hour. Galls may be expected on any kind of seed plant, including grasses, weeds of all sorts, bushes, and trees. They may be found on the leaves, stems, or roots, and in the buds, flowers, or fruits of the plant. They may be slight swellings of the normal plant tissues, or large swellings, or structures with special forms, being sometimes growths that are easily detached.

Look for galls attached to the plants, or loose on the ground beneath the plants, or attached to the dead leaves, acorns, etc., that have fallen to the ground.

Some plants that are (among many others) especially liable to bear galls are:

Cedar trees (*fungus galls*)
Fir and spruce trees (*plant louse galls*)
Willows and poplars (*mostly midge, sawfly, and plant louse galls*)
Hickory (*mostly plant louse galls*)
Oak (*mostly wasp galls*)
Witch hazel (*plant louse and midge galls*)
Roses and blackberries (*wasp galls*)
Maple leaves (*midge and mite galls*)
Goldenrod (*fly, midge, and moth galls*)
Wild lettuce, resin weed, rabbit brush (*wasp galls*)
Other stout-stemmed weeds (*various galls*)

B. For each gall examined, try to discover what part of the plant it is that has been changed into this abnormal growth. No really new plant tissues have been produced in the gall, but a very different arrangement of these tissues has been caused by the presence of the gall maker.

We shall be able to show that certain plant materials exist in abnormal quantities in the gall. Place a few oak galls (or rose or sumac galls)

in water, cutting them to allow the water to penetrate. Note the effect on the water. After a few minutes put a clean piece of paper (or better, an untanned piece of leather) in the water with the galls and note results. The color secured is characteristic of *tannin*, a material found sparingly in most plant tissues, but amounting to 20 per cent. or 30 per cent. or even 65 per cent. in some oak galls.

Dip a clean knife blade or some other piece of polished iron or steel in the water containing the oak galls. Note the effect within a few minutes. If iron filings are available, put them in clear water with a piece of an oak gall. You have now made ink in much the way that most ink was made until recent years. The fine purple black color is produced only when iron and gallic acid come together. *Gallic acid* is another plant material found in quantity in insect galls.

Report the galls you study in a table similar to the following:

Galls found (use your own names for them)	Kind of plant	Part of plant deformed

Teaching Note.—In every part of the country, galls may be had in the field at every season in the year. They are most abundant throughout the fall and again in the late spring, but they are also obtainable in the winter.

A laboratory exercise may be made by using dried specimens of galls (most species are easily kept dry without special preparation), and emphasizing part B instead of part A of this outline.

Ecology *or* General
One field period
Kinsey BIOLOGY, pp. 226–354

MID-WINTER PLANTS AND ANIMALS

Object.—To observe how some of the plants and animals spend a mid-winter day.

Materials.—None—except warm clothing and stout shoes.

Procedure.—If you live in a locality with a cold winter, you will find the out-of-doors unusually interesting at this season. The trip will be most profitable about twenty-four hours after a light snowfall.

What evidences can you find of animal activities?

Active insects of a few species may be found on the surfaces of the snow.

Other live insects, even including a butterfly or two, may be found on some warm and sunny spot, on the protected side of a large tree, on the sunny side of a hay or straw stack, or about some open spot in the icy brook or pond.

Hibernating insects and spiders of many sorts may be found under a loose piece of bark, under a board, or in loose debris.

Insect larvæ may be uncovered if you slit down the frozen stalk of some dead weed or corn-plant.

Look for mammal tracks in the snow or thawed-out ground about water. Learn to identify the animal from its tracks (see some of Thompson Seton's publications).

Squirrels and rabbits leave four marks close together: which way are they going? Coons, cats, dogs, and their wild relatives will show the marks of each toe. Mice will leave tiny footmarks in a double row (some species also show a tail-mark down the middle of the track). Did you ever know there were so many mice as the tracks about some tree stumps indicate? Shrews with their very short legs may leave a solid furrow like an inch-wide wagon track through the snow. Wet snow dripping from trees and bushes will leave fairy-like tracks everywhere.

Follow the animal tracks. Was the creature going slowly or fast? Was it a small or large individual? Where is it now?

Look for birds in warm and sunny places protected from the wind. Look near clumps of evergreens, and in protected hollows, canyons, or ravines.

What kinds of birds can you find? Have they been here all year or

have they come in for the winter? Where from? What are they eating? What was the food of the birds that first migrated south in the fall? Why do these birds not freeze in winter? Explain what you need to know about metabolism and mattresses.

What is the plant world doing at this season? Break a branch of a tree to see if it is frozen. Note the evergreens. What advantage is it to them to have such narrow leaves? Examine the winter buds of the other trees, noting the varnish, fuzz, or other protection. Explain why these are *not* protections from the cold. Then from what do they protect the bud?

Look for winter rosettes of leaves close to the ground. These are usually leaves of the biennials (plants like wild lettuce, thistle, mullein, dandelion, burdock, etc., which grow a leafy rosette the first year and the flower stalk the second year). What sort of protection does each have from animals and from the winter? Again, these are not protected from the cold, but from something else.

Ecology
One field period
Kinsey BIOLOGY, pp. 296–298, 310

MOSQUITO BREEDING PLACES

Object.—To discover all the places in a given area in which mosquitoes are breeding or might breed.

Materials.—Pencil and paper.

Procedure.— Let the class be divided into groups of 4 or 5 students each. Each group will be assigned a limited area (1 city block, or 3 or 4 acres of more open country).

Each group should carefully explore the assigned territory, making a list of all the places in which mosquitoes are breeding or might be expected to breed. Don't miss any stray tin can, sewer catch basin, bucket, mud-puddle, or other place that can hold water for the ten days necessary for the development of some of our common mosquitoes.

Each student should write a brief report of his survey with recommendations for improving the situation *in his particular area.* If breeding places were few or absent, let the report explain why.

Teaching Note.—This work is best managed in the fall or spring, but in many parts of the country the weather is not too severe to allow the class out-of-doors in mid-winter. The mosquito-breeding places should be apparent as long as the ground is not covered with snow.

Distribution
Two laboratory periods
Kinsey BIOLOGY, pp. 355–358

RANGES OF PACIFIC COAST ORGANISMS

Object.—To examine the known ranges of some Pacific Coast species of plants and animals.

Materials.— For two students: A good atlas, or Rand-McNally pocket maps of California, Oregon, and Washington. An outline map of the Pacific Coast. A set of colored crayons. In addition, lists of localities such as those given below.

Procedure.— Accompanying this exercise are lists of the actual localities at which certain organisms have been collected by scientists. The teacher will assign the mapping of *one* of these organisms to each pair of students.

Look up each locality in the index of the atlas or pocket map. From the reference numbers there given (such as C8, F3, etc.), locate each name on the map. Then make a small pencil mark in a corresponding place on the outline map.

If you are mapping more than one variety of a single species, use a distinctive mark (such as figures 1, 2, 3, etc.) for each variety.

Finally, with the colored crayons make a circular spot (⅛ to ¼ inch in diameter) for each locality record on your outline map. Use a distinctive color for each variety of a species.

Carefully study the questions below before drawing your conclusions.

Questions.—Do scientists have very much knowledge of the distribution of the organism that you have mapped?

Is the range continuous or discontinuous?

Are the boundaries of the range fairly sharp, or do the boundaries extend irregularly?

Is the range a large or a small part of the world?

Do the ranges of the related varieties overlap completely or in part?

Coral Leaf Gall (*Cynips echinus*)

Variety A. *California:* Paso Robles, Pasadena, Upland, El Toro, Sorrento, Fallbrook, Alpine, Jacumba.

Variety B. *California:* Redding, Shasta County, Inskip, Kelseyville, Oroville, northeastern Napa County, Napa, Sonoma County, St. Helena, Battle Creek, eastern Placer County, Colfax, Contra Costa County, Diablo, San José, Morgan Hill, Hornitos, Paso Robles, Dinuba, Kern County, Three Rivers.

Variety C. *California:* Kelseyville, northern Lake County, southern Lake County, northwestern Lake County, western Lake County, Dinuba.

Variety D. *California:* Victorville, northeastern Los Angeles County.

California Oak Apple Gall (*Andricus californicus*)

Variety A. *California:* Grant, Exeter, Three Rivers, San José, Woodland, Kelseyville, Anderson, Merced Falls, El Portal, Paso Robles, Byron, Oakdale, Gilroy, Palo Alto, Redwood City, San Francisco, Mt. Diablo, Santa Rosa, Napa, Galt, Oroville, Redding, Klink, Middletown, Livermore, Marysville, Tulare, Concord, Orange Cove, Dinuba, Walnut Creek, Berkeley.

Variety B. *California:* Yreka, Hanburg. *Oregon:* Ashland, Grant's Pass, Roseburg, Junction City, Canby, Eugene. *Washington:* Olympia, White Salmon, South Tacoma.

Variety C. *California:* Descanso, Alpine, Fallbrook, Sorrento, El Toro, Upland, Pasadena, Paso Robles, Jacumba, Monrovia, Claremont, Ontario, Azusa.

Coast Garter Snake (*Thamnophis ordinoides atratus*)

Oregon: Siskiyou. *California:* Anderson, Gasquet, Requa, Trinidad, Eureka, Ferndale, Alton, Carlotta, Cuddeback, Garbersville, Covelo, Laytonville, Sherwood, Mendocino, Comptche, Ukiah, Point Arena, Pieta, Gualala, Middleton, Rumsey, Cazadero, Ducans Mills, Austin Creek, Kidd Creek, Guerneville, Freestone, St. Helena, Vacaville, Iverness, Point Reyes, Tocaloma, Olema, Mill Valley, San Rafael, Sausalito, Diablo, Walnut Creek, Berkeley, Oakland, San Leandro, San Francisco, San Bruno, Portola, Woodside, Corte Madera Creek, La Honda, Pescadero, Stanford University, Palo Alto, Los Gatos, Santa Clara, San José, Mt. Hamilton, Gilroy, Hot Springs, Swanton, Waddell Creek, Felton, Glenwood, Soquel, Blanco, Seaside, Pacific Grove, Carmel, Morro, Oceano, Santa Ynez River.

California White Oak (*Quercus lobata*)

California: Trinity River, Mariposa, Raymond, San Benito, Jolon, Visalia, Caliente, Anderson, Shasta, Saugus, Santa Barbara, San Fernando, Santa Monica, San Antonio River, Chico, Kelseyville, Big Oak Flat, Bachelor, San Ramon, Suisun, Potter Valley, Solano County, Monterey, Grant, Exeter, Three Rivers, Merced Falls, Marysville, Calistoga, Chico, Durham, El Portal, Paso Robles, Byron, Oakdale, Gilroy, Palo Alto, Stockton, Lodi, Wallace, Nashville, Eldorado, Shingle Springs, Redwood City, San Francisco, Diablo, Santa Rosa, Coloma, Lotus, Jackson, Oleta, Volcano, Westpoint, Napa, Galt, Oroville, Redding, Round Valley, Laytonville, Mt. Tamalpais, Shellville, Middletown, Lakeport, Cortena, Sittes, Stonyford, Woodland, Davis, Yolo, Biggs, Clippergap.

California Blue Oak (*Quercus douglasii*)

California: Santa Ynez, Tehachapi Mts., Ukiah, San Francisco, Pitt River, McCloud, Shasta, Redding, Encino, Inskip, Kelseyville, Oroville, Napa, St. Helena, Colfax, Diablo, San José, Morgan Hill, Hornitos, Paso Robles, Dinuba, Kern County, Round Valley, Santa Rosa, Red Bluff, San Fernando, Jolon, Monterey County, Windsor, Kaweah, southern Lake County, Cupertino, Stanford University, Palo Alto, Byron, Oakdale, Three Rivers, El Portal, Auburn, Merced Falls, Placerville, Tuolumne River, Hot Springs.

Two Western Garter Snakes (*Thamnophis ordinoides vars.*)

Variety A. *British Columbia:* Friendly Cove, Lund, Alberni Valley, Union Bay. *Washington:* Forks, Whatcom, Mount Vernon, Darrington, Seattle, Mt. Ranier, Port Orchard, Montesano, Melbourne, Aberdeen, Lebam. *Oregon:* Astoria, Gearhart, Portland, Garibaldi, Trask River, Tillamook, Dolph, Toledo, Philomath, Alsea, Elmira, Marshfield, Sumner, Coquille, Myrtle Point, Drain, Sixes River, Port Orford, Elk Creek, Rogue River, Corbin, Gold Beach, Harbor. *California:* Smith River, Gasquet, Crescent City, Requa.

Variety B. *California:* Carmel, San Antonio, Nacimiento, Cottonwood, Battle Creek, Orland, Stony Creek, Strawberry Valley, Fyffe, Pleasant Valley, Yosemite Valley, Los Banos, Gadwall, Raymond, Hume, Fresno, Little Kern River, Bueno Vista Lake, Bodfish, Owens Lake, Laws, Lake Tahoe, Fallen Leaf, Tallac, Tahoe. *Nevada:* Glenbrook, Wadsworth, Pyramid Lake.

Two More Garter Snakes (*Thamnophis ordinoides vars.*)

Variety A. *California:* Oroville, Strawberry Valley, Soda Springs, Fyffe, Tuolumne Meadows, Yosemite Valley, Kings River (near headwaters), Monache, Sierraville, Fallen Leaf, Tallac, Lake Tahoe, San Bernardino Mts., Santa Ana River, Sugar Loaf Mts. *Nevada:* Glenbrook.

Variety B. *California:* Oceano, Santa Ynez River, Santa Paula, Pasadena, Los Angeles, Claremont, Rock Creek, Victorville, Santa Ana River, San Bernardino Mts., Ontario, Chino, Riverside, San Jacinto, Keen Camp, Hemet, Cabazone, Laguna Beach, Oak Grove, Carlsbad, Santa Ysabel, Descanso, Sweetwater Dam, Dulzura, Campo.

Two Western Mosquitoes

A. (*Culex comitatus*). *California:* National City, San Diego, Sweetwater Junction, Laguna, Avalon, Los Angeles, San Pedro, San Luis Obispo, Stanford University.

B. (*Aëdes varipalpus*). *British Columbia:* Kaslo, Vancouver, Nanaimo, Wellington, Victoria. *Washington:* Seattle, Kent. *Oregon:* Ashland, Portland. *California:* Dunsmuir, Fieldbrook, Humboldt County, Eureka, Stanford University, Stockton, San Raphael, Pasadena, Claremont. *Arizona:* Williams. *Nevada:* Glenbrook.

Four Varieties of Golden Bush or Rabbit Brush

(*Chrysothamnus nauseosus*)

Variety A. *Nevada:* Carson Sink, Lyon County, Candelaria, Pyramid Lake, Fallon, Reno, Goldfield. *California:* Benton, Inyo County, Lancaster, Bishop, Banning, Colton, Kearsarge, Rosamond, Saugus, Barstow.

Variety B. *British Columbia:* Tranquille. *Montana:* Polson. *Washington:* Wawawai. *Oregon:* Warmspring. *California:* Plumas County, Modoc County, Lassen County.

Variety C. *California:* San Gabriel Mts., San Bernardino Mts., San Jacinto Mts.

Variety D. *California:* Mojave, Mojave Desert, Greenhorn Mts., Alamo Mts., north side San Gabriel Mts., Coalinga.

White Oak Stem Gall (*Neuroterus quercicola*)

Variety A. *California:* Oroville, Cupertino, San José, Stanford University, Sunol, Metz, Mt. Diablo, Zelzah, Gilroy, Coalinga, Three Rivers, Exeter, Paso Robles, San Luis Obispo, Byron, Galt, Redding, Klink.

Variety B. *California:* San Diego, El Toro, Pasadena, Upland, Paso Robles, Monrovia.

Variety C. *Washington:* Friday Harbor. *Oregon:* Ashland, Canby.

Southern California Human Population

(*Towns over 1000*)

California: Chino, Claremont, Coronado, Downey, Escondido, Highland, Hollywood, Huntington Park, Imperial, Inglewood, Needles, Sierra Madre, Watts, Bishop, Covina, El Centro, Fullerton, Alhambra, San Pedro, Santa Monica, Pomona, Redlands, Santa Ana, Riverside, San Bernardino, Anaheim, Glendale, Redondo Beach, San Diego, Los Angeles, Orange, Sawtelle, Upland, Wilmington, Colton, Corona, Monrovia, Ocean Park, East San Diego, Ontario, South Pasadena, Venice, Whittier, Long Beech, Pasadena.

Central California Human Population

(Towns over 2500)

California: Elmhurst, Marysville, Merced, Napa, Oak Park, Petaluma, Richmond, San Luis Obispo, San Rafael, Santa Rosa, Eureka, Santa Barbara, Santa Cruz, Vallejo, Bakersfield, Angels Camp, Chico, Oroville, Redding, Red Bluff, Salinas, San Leandro, Woodland, Alameda, Fresno, Stockton, San José, Watsonville, Coalinga, Grass Valley, Hanford, Modesto, Monterey, Palo Alto, San Mateo, Santa Clara, Visalia, San Francisco, Oakland, Berkeley, Sacramento, Emeryville, Hayward, Porterville, Lodi, Mill Valley, Nevada City, Oxnard, Roseville, Tulare, Ventura.

Teaching Note.—Maps taken from the Rand-McNally or other commercial pocket map series (obtainable from drug stores at about 35 cents each), and mounted (with flour and water paste) on large sheets of cardboard, are the most convenient materials for this exercise. The outline maps for this and the following exercises are also obtainable from Rand-McNally, Chicago, or from the Milton Bradley Company, Springfield, Mass., or from the McKinley Publishing Co., Philadelphia, Pa.

While this exercise would be more pertinent if it included species native to your own state, it seems impracticable to include such lists even if they were obtainable. Further lists may be found in the following among other references:

Blanchard, F. N., 1921. A Revision of the King Snakes: Genus Lampropeltis. U.S. Nat. Mus. Bull. 114, Government Printing Office, Washington, D.C.

Hall, H. M., and F. E. Clements, 1923. The North American Species of Artemesia, Chrysothamnus, and Atriplex. Carnegie Institution, Washington, D.C.

Howard, L. O., and H. G. Dyar and F. Knab, 1915–1917. The Mosquitoes of North and Central America and the West Indies (Vols. 3–4). Carnegie Institution, Washington, D.C.

Jepson, W. L., 1910. The Silva of California. University Press, Berkeley, Calif.

Piper, C. V., 1906. Flora of the State of Washington. U. S. Government Printing Office, Washington, D.C.

Sudworth, G. B., 1908. Forest Trees of the Pacific Slope. U. S. Government Printing Office, Washington, D.C.

Van Denburg, J., 1922. The Reptiles of Western North America (2 Vols) Calif. Acad. Sci., San Francisco.

Wooten, E. O., and P. C. Stanley, 1915. Flora of New Mexico. U. S. Nat. Herb., Vol. 19, Government Printing Office, Washington, D.C.

Distribution
Two laboratory periods
Kinsey BIOLOGY, pp. 355–358

RANGES OF EASTERN AMERICAN ORGANISMS

Object.—To examine the known ranges of some Eastern American plants and animals.

Materials.—For two students: A good atlas, or Rand–McNally (or other) pocket maps of each state concerned in the exercise. An outline map covering the same area. A set of colored crayons. Also the lists of localities given below.

Procedure—Follow the procedure of the previous exercise, working this time with an Eastern American organism.

Questions.—Answer once again the questions asked with the preceding exercise.

Do you find the ranges of this species or of the varieties larger or smaller than the ranges of the Pacific Coast organisms you studied? Why?

Hedgehog Gall on Oak (*Cynips pezomachoides*)

Variety A. *Ontario:* Toronto. *Massachusetts:* Forest Hills, Framingham. *Connecticut:* Waterbury. *New York:* Waterport, Ithaca, Syracuse. *Pennsylvania:* Highspire. *D.C.:* Washington. *Virginia:* Bluemont, Big Stone Gap, Natural Bridge. *West Virginia:* Beckley. *North Carolina:* Murphy. *Ohio:* Elyria, Wooster, Columbus, Rockport. *Indiana:* Porter, Roachdale, Greencastle, Bloomington, Spencer, Bedford, Mitchell, Crothersville. *Illinois:* Winnetka, Evanston, Glencoe, Glen Ellyn, Moline, Willow Springs, Ravinia. *Michigan:* Agricultural College. *Wisconsin:* Green Lake. *Minnesota:* Robbinsdale. *Iowa:* Ames. *Kansas:* Riley County. *Missouri:* Barnhart, St. Louis, Kimmswick, Imperial, Edgar Springs, Allentown.

Variety B. *Massachusetts:* Cambridge, Forest Hills. *Connecticut:* Stamford, Waterbury. *New York:* Albany, New York City, Oakwood, Riverhead, Manorville. *New Jersey:* Fort Lee, Patterson, Greenwood Lake, Orange Mts., Carlstadt, Lakehurst, New Brunswick, Medford, Pittman, Richland, Carmel. *Pennsylvania:* Philadelphia. *Maryland:* Baltimore. *D. C.:* Washington. *Virginia:* East Falls Church, Eastville. *West Virginia:* Beckley. *North Carolina:* Cherokee, Marshall.

Variety C. *Massachusetts:* Blue Hills, Sherwood, Framingham, Melrose Highlands, Magnolia. *Michigan:* Flint.

Downy Oak Marble Gall (*Cynips fulvicollis*)

Variety A. *Ontario:* Toronto. *Massachusetts:* Forest Hills, Framingham. *Connecticut:* Waterbury. *New York:* Albany, Ithaca, Riverhead. *D.C.:* Rock Creek. *Ohio:* Columbus. *Michigan:* Manistee, Interlochen, Ionia County. *Indiana:* Porter, Delphi, Mitchell, Spencer. *Illinois:* Evanston, Glencoe, Glen Ellyn, Fountaindale. *Iowa:* Corinth, Ames. *Nebraska:* Nebraska City. *Missouri:* Kimmswick, St. Louis.

Variety B. *Indiana:* Charlestown. *Kentucky:* Dawson Springs, Paducah. *Missouri:* Rankin, Arcadia, Poplar Bluff. *Arkansas:* Winslow. *Kansas:* Winfield, Silverdale, Holton, Manhattan, Leavenworth.

Variety C. *New York:* Albany, New York City. *New Jersey:* Fort Lee, Bennett. *D.C.:* Washington. *Virginia:* Bluemont, Natural Bridge. *Indiana:* Bedford, Spencer. *Kentucky:* Wickliffe, Paducah.

Two Eastern Mosquitoes

A. (*Anopheles crucians*).—*New York:* Bellport. *New Jersey:* Cape May, Elizabeth, Manumuskin, Delair. *Maryland:* Chesapeake Beach, Ocean City, Laurel, Woodbine, Piney Point. *Virginia:* Virginia Beach, Richmond, Lake Drummond. *North Carolina:* Hendersonville. *South Carolina:* Columbia, McClellanville. *Florida:* Melbourne, West Palm Beach, Lake Okeechobee, Estero, Jacksonville, Kissimmee, Sanford, Tampa, Fort Myers, Arcadia. *Louisiana:* Lake Catherine, New Orleans. *Mississippi:* Biloxi. *Texas:* Buenos, Galveston, Tyler. *Arkansas:* Scott.

B. (*Aëdes impiger*).—*Massachusetts:* West Springfield, Longmeadow. *New York:* Elizabethtown, Karner. *Ontario:* Ottawa, White River.

Second Pair of Eastern Mosquitoes

A. (*Psorophora columbiæ*).—*New York:* Cold Spring Harbor. *New Jersey:* Delair. *West Virginia:* Kanawha Station. *Maryland:* Hyattsville. *D.C.:* Washington. *Virginia:* Woodstock, Grassymead, Arlington, St. Elmo, Del Ray. *Missouri:* St. Louis. *Georgia:* Atlanta. *North Carolina:* Greensboro. *Tennessee:* Rives. *Kentucky:* Corbin. *Arkansas:* Little Rock, Scott. *Mississippi:* Agricultural College, Tutwiler, Jackson, Belzoni, Clarksdale, Yazoo. *Louisiana:* Johnson's Bayou, New Orleans.

B. (*Aëdes fuscus*).—*New Hampshire:* Center Harbor. *Massachusetts:* Springfield, Westfield, Longmeadow. *Connecticut:* Hartford. *New York:* Tupper Lake, Plattsburg, Ithaca. *New Jersey:* Delair. *Wisconsin:* Madison Saxeville. *Manitoba:* Winnipeg. *Saskatchewan:* Oxbow.

A Third Pair of Eastern Mosquitoes

A. (*Culex dyari*).—*New Hampshire:* Center Harbor. *Massachusetts:* Springfield. *Connecticut:* Suffield, Branford. *New York:* Tupper Lake. *New Jersey:* Culvers Lake. *Wisconsin:* Saxeville. *British Columbia:* Kaslo.

B. (*Psorophora horridus*).—*Texas:* Victoria, Greenville, Dallas. *Mississippi:* Westpoint, Corinth, Jackson. *Arkansas:* Van Buren, Fort Smith, Little Rock, Danville, Helena, Scott. *Tennessee:* Chattanooga. *Oklahoma:* Wister. *Virginia:* Woodstock. *Maryland:* Plummers Island. *D.C.:* Washington.

Speckled King Snake (*Lampropeltis getulus holbrooki*)

Texas: Galveston, Matagorda, Arthur, Dallas, Clifton. *Oklahoma:* Fort Towson, Caddo County, Tulsa County, Comanche County, Wister, Sugar Loaf Mts., Fort Supply. *Kansas:* Shawnee, Fort Riley, Jefferson County, Manhattan, Twin Mounds, Coffey County, Osage County, Jefferson County, Trego County, Labette County, Anderson County. *Missouri:* Irondale, St. Louis County, Galena, Crawford County, Stone County, Phelps County, Howell County, Oregon County, St. Charles County, Jefferson County. *Iowa:* Columbus Junction. *Nebraska:* Cook. *Illinois:* Mount Carmel, St. Clair County, Horseshoe Lake, Olive Branch. *Tennessee:* Samburg. *Arkansas:* Jefferson County, Garland County, Arkadelphia, Greenway, Donaldson, Fayetteville. *Alabama:* Mobile County, Duncanville, University, Mobile. *Mississippi:* Natchez, Kemper County, Cat Island, University. *Louisiana:* New Orleans, St. James County.

Three Southern Varieties of King Snake

Variety A. *New Jersey:* Bridgeton, Point Pleasant, Port Republic, Vineland, Lakewood, Lakehurst, Beesleys Point. *Delaware:* Seaford. *Maryland:* Laurel, Sandy Spring, Hyattsville, Norbeck, Annapolis Junction, Williams. *D.C.:* Washington. *Virginia:* Midway Mills, Occoquan Creek, Rappahannock County, Dunn-Loring, Chancellorsville, Mount Vernon, Lake Drummond, Virginia Beach, Dismal Swamp, Hampton, Chilesburg, New London, Gloucester, Southampton County. *North Carolina:* Newbern, Lenoir, Cherokee, Wilmington, Raleigh. *South Carolina:* Anderson, Wando, Bluffton, Hampton County, Hilton Head. *Georgia:* St. Simons Island, Augusta, Marietta, Baconton, Fargo, Savannah, Okefinokee Swamp. *Florida:* Cedar

Keys, Indian River, Gainesville, Fernandina, Orange Lake, Eustis, Marion County. *Alabama:* Baldwin County, Daphne.

Variety B. *Florida:* Charlotte Harbor, Orange, Hammock, Kissimmee, Lake Kissimmee, Lemon City, Prairie, Orlando, Gotha, Vero.

Variety C. *Florida:* Royal Palm State Park, Homestead.

Wrinkled Warble Gall (*Cynips mellea*)

Variety A. *Arkansas:* Hoxie, Little Rock, Hot Springs, Texarkana, Hope. *Texas:* Arlington, Palestine, Trinity, Cuero, Boerne, Austin, Round Rock, Leander, Hearne, West Point, College Station, Houston, Sinton. *Mississippi:* Pass Christian. *Florida:* Milton.

Variety B. *New York:* Nyack. *New Jersey:* Fort Lee, Lakehurst, Richland, Carmel. *Virginia:* Eastville, Cape Charles. *North Carolina:* Ashville, Marshall, Cherokee. *Kentucky:* Dawson Springs. *Tennessee:* Newport. *Missouri:* Dexter.

Variety C. *Florida:* Jacksonville, Greencove Springs, Madison, Ocala, Carabelle, Clearwater, St. Petersburg, Daytona.

Variety D. *New Mexico:* Las Vegas Hot Springs, Wagon Mound, Shoemaker.

Variety E. *Missouri:* Ironton, Arcadia, Dexter, St. Louis, Poplar Bluff. *Kentucky:* Dawson Springs.

Southwestern Oak-Apple Gall (*Cynips dugèsi*)

Variety A. *Colorado:* Manitou, Colorado Springs, Wetmore, West Cliff, La Veta, Spanish Peaks, Trinidad, Morely. *New Mexico:* Raton, Wagon Mound, Shoemaker, Glorieta, Las Vegas Hot Springs, Tijeras.

Variety B. *Texas:* Alpine, Fort Davis.

Variety C. *New Mexico:* Magdalena, Alamogorda, Highrolls, Hillsboro, Kingston. *Arizona:* Prescott, Safford, southern Santa Catalina Mts., Oracle, Santa Rita Mts., Courtland, Fort Huachuca, Bisbee.

Teaching Note.—See the teaching note with the previous exercise. It proves advantageous to have the students work both this and the preceding exercise, the comparison of the life zones of the western and eastern parts of the country having numerous points of interest.

Distribution
One laboratory period
Kinsey BIOLOGY, pp. 364–377

LIFE ZONES

Object.—To map some American life zones by studying the ranges of a small number of organisms.

Materials.—The maps of ranges studied by the class in the two previous exercises. An outline map of the United States. A set of colored crayons.

Procedure.—All of the maps made by the class in the two previous exercises will be passed around so each student may study each map (or as many as time allows).

On a new outline map of the United States, draw single lines outlining the range of each variety you study. Do not attempt to copy each locality record, but make an outline that, roughly, will include the limits of each range.

Now your map will show a tangled mass of overlapping and crossed lines, like a disorderly collection of bent and distorted wire rings.

Can you find places in the country where a number of these lines lie more or less on top of each other, or lie parallel and close to each other? If so, draw a colored line that will represent a sort of average of these several ranges that nearly agree.

The area within each colored line will roughly represent a life zone. Color each area to make it more evident. It would require a study of the ranges of many more organisms and a study of the climatic, geographic, and geologic conditions of each region to make us sure of our results, but this exercise will help explain what we mean by a life zone.

Distribution
One laboratory period
Kinsey BIOLOGY, pp. 364–367, 361

GEOGRAPHIC FACTORS OF LIFE ZONES

Object.—To note some of the geographic factors that help establish the boundaries of our American life zones.

Materials.—One United States relief map. One United States outline map. Colored crayons.

Procedure.—Work in pairs.

Carefully examine the United States relief map until you have gone over the entire country. The height of the land is indicated by the color.

From this map, you may secure information about the following, which are more or less important as factors of distribution:

Height of land (elevation above sea level).

Presence or absence of high mountain barriers.

Amount of rainfall (indicated by the number of large rivers in any area).

Distance from another life zone of the same elevation.

Latitude.

Using the information that the relief map furnishes, see how many life zones you would *expect* in the United States. Be sure you use only the information that the relief map furnishes. Do not get too many life zones.

On an outline map of the United States draw in the boundaries of the life zones that your relief map would lead you to expect. You may color the map with crayons to make the results more apparent.

Now compare your results with a true life zone map (such as that on page 368 of the Kinsey Biology).

Are there any cases where the relief map agreed with the life zone map?

Where are the most outstanding cases of disagreement between the relief map and the life zone map? Can you discover the reasons for any of this disagreement?

Don't forget that there are organic, climatic, geologic, and still other factors of distribution which your relief map did not show.

Teaching Note.—For this exercise and the exercise on Arctic-Alpine areas, secure U.S. relief (hypsometric) maps, 18 x 28 inches, from the director of the U.S. Geological Survey, Washington, D.C. They cost 15 cents each, or 9 cents in orders amounting to $3.00 or more. Provide enough of these maps to let each pair of students have one to work with.

Distribution *or* Ecology
One field period
Kinsey BIOLOGY, pp. 367, 226–235

HABITATS

Object.—To observe some of the habitats of local plants and animals, and to note some of the ecologic conditions of each habitat.

Materials.—A pencil and paper.

Procedure.—The teacher will take the class to as varied a piece of country as is available.

The students will try to discover and name each distinct grouping of plants (and consequently of the animals found there). The following list will suggest the sorts of habitats you may find. Invent your own names for additional kinds.

City vacant lot
City park
Dusty roadside
Roadside ditch
Old field
Cultivated field
Meadow
Briar patch
Second growth brush
Mixed woods
Beech woods
Spaghnum swamp
Grass swamp
Laurel swamp
Deep-water swamp
Cypress swamp
Bog
Rocky lake shore
Swampy lake shore
Sandy lake shore
Meadow brook
Mountain stream
Oak woods
Pine woods
Hemlock woods
Burnt woods
Burnt thicket
Birch thicket
Rhododendron thicket
Mesquite thicket
Manzanita thicket
Chaparall
Dry swamp
Rocky hillside
Dry canyon (or ravine)
Wet canyon (or ravine)
Barren desert
Alkaline desert
Sage-brush desert
Cactus desert
Sand beach
Sand dune
Rocky coast

Do not overlook the variety of conditions with which you are familiar but which, because of their familiarity, you may fail to realize. For instance, from a single spot near a middle western town, one time, we

were able to observe a mixed forest, a cleared field, a cultivated field, an old field, a briar patch, a second growth woods, a mixed forest, and a beech woods. But it took the class nearly an hour to realize there was anything more than a field and a forest to observe! At the same time, the fact that each of these habitats had succeeded (originated from) the other in the list became perfectly evident.

Each student will keep a list of the kinds of habitats found, the names of the most prominent plants (or animals) in each, and notes on any of the conditions (soil moisture, human influences, etc.) which are the chief distributional factors in each of these habitats. It is not necessary for our present purposes to make lists of very many of the species found in each habitat; popular names of the one or two most conspicuous plants will suffice (*e.g.*, hemlock forest, briar patch, laurel swamp, mesquite desert, etc.).

Keep a record something like this:

Habitat	Most conspicuous plants	Chief factors affecting organisms

Teaching Note.—Even in the late fall, winter, or early spring the nature of these habitats will be evident and this trip possible.

Distribution
One laboratory period
Kinsey BIOLOGY, pp. 378–391

ARCTIC-ALPINE AREAS

Object.—To locate the chief Arctic-Alpine areas of the United States.

Materials.—One United States relief map. An outline map of the United States. Colored crayons.

Procedure.—Carefully examine the United States relief map. The height of land is indicated not only by the color, but also by numbers on the irregular lines (contour lines) that are everywhere on the map, and that make irregular circles and ellipses about mountains.

Locate all the places in the United States that are high enough to have an Arctic-Alpine fauna and flora. Indicate these places with colored crayons or ink on your outline map.

Tree line is at *about* the following elevations in various parts of the country:

Northeastern States (north of the Ohio River and Maryland, and east of Kansas and the Dakotas): At about 4500 feet.

Southeastern States (south of the Ohio River and Maryland, and east of Oklahoma and Texas): At about 7500 feet.

Northern Rocky Mountains (Dakotas, Wyoming, Montana, Idaho): At about 10,000 feet.

Northern Pacific Coast (Washington, Oregon, and the northern quarter of California): At about 6000 feet further north, to 7500 feet further south.

Central Rockies and Central Sierras (Colorado, Utah, and central California): At about 11,000 feet.

The Southwest (Texas, New Mexico, Arizona, and southern California): At about 12,000 feet.

Teaching Note.—The relief maps for this exercise are the maps used in the exercise on Geographic factors of Life Zones.

Distribution
One laboratory period
Kinsey BIOLOGY, pp. 367–404

LIFE ZONES AND REGIONS

Object.—To discover which of the American life zones and the regions of the world most often supply advertising materials.

Materials.—Several old magazines that contain an abundance of advertising.

Procedure.—Each student will be asked to bring a number of old magazines that contain a goodly amount of advertising. These will be circulated about the class during the period and you will study as many of them as possible.

Study every illustrated ad that includes any plants or animals in its illustration. Can you figure out from the plants, animals, people, or landscapes shown in the pictures, or from the text accompanying them, which of our American life zones or which of the other regions of the world are represented in these pictures? See pages 367–404 in the Kinsey Biology for the names of these zones and regions.

Keep a record something like this:

Life zone or region	No. of times shown in ads	No. of times plants or animals are chief features of ads

Do not record any ad unless you are sure of the life zone it represents. But keep your eyes open for corners of scenery in the advertisements, as well as for the larger pictures.

In all, how many of our American life zones are ever of importance to advertisers? Why are these certain ones used more often than others?

Which of those that are not used would provide as interesting material for advertisements? Why wouldn't the life zone in which you live make as interesting advertising material?

Behavior *or* Physiology
One laboratory period
Kinsey BIOLOGY, pp. 406, 74

THE SENSE OF TOUCH

Object.—To determine the location of the organs most sensitive to touch in the skin of the human.

Materials.—For two students: A pair of forceps, several small elastic bands. A small rule.

Procedure.—Let two students work together.

Twist a rubber band several times about the forceps near their tips, in such a way that by slightly moving the band up or down on the instrument the tips will spread further apart or come closer together. (A draughtsman's dividers work more simply, but are less readily available.)

Blindfold student A (the *subject*). Set the points of the forceps ½ inch (or 15 mm.) apart. Student B (the *observer*) will touch either one point alone, or both points *at exactly the same time*, to the back of the hand of the subject. Let the subject state whether one or two points touched him. Repeat 25 times with the forceps at the same spread, sometimes touching one, sometimes two points. Allow plenty of time between trials so that one sensation is completely gone before another comes.

Record the number of times the answers are correct, remembering that there are 5 chances out of 10 that they will be correct even when the subject is guessing!

Repeat 25 times with the tips of the forceps spread for each of the following, ⅜, ¼, ⅛, ,1/16 inch (or 10, 5, 3, 1 mm.).

Repeat the whole exercise with student B as the subject and student A as the observer.

Similarly test for other parts of the body on each student: the palm of the hand, the tip of the thumb, the tip of the index finger, the wrist over the pulse, the back of the neck, the cheek, the tip of the nose, the tongue, etc., as far as you have time.

Record your results in a table similar to the following:

Part Studied	Student	Number of Correct Perceptions at					Smallest distance with 50 per cent. or better correct
		½″	⅜″	¼″	⅛″	1/16″	
Back of hand . . .	A B						
Palm of hand . . .	A B						
Tip of thumb . . .	A B						
Tip of index finger	A B						

Compare your results with those for the whole class, noting the individual variation.

List the part (or parts) with the keenest sense of touch for each of the students of the class.

Questions.—Why was it necessary to take so many measurements (25) on each part?

Did one of the two students have the keener touch in *every* part tested? Prove from your experiment.

Discuss the individual differences observable in the class.

What advantage to an animal is there in having the most delicate touch organs located where they are?

Behavior, Physiology, *or* Scientific Method
Two laboratory periods
Kinsey BIOLOGY, pp. 406, 74

THE TEMPERATURE SENSE

Object.—To determine the location in the skin of the nerve endings that are sensitive to temperature stimuli.

Materials.—For two students: A dozen (or more) long wire nails A jar or can of hot water (or a burner to keep it hot). A container of cold water with broken ice to keep it cold. A container of water at room temperature. Forceps. Pen. Three colors of ink. A rule.

Procedure.—Two students will work together.

Several nails should be kept hot in water too hot for one's hand, but not hot enough to boil. Several nails should be kept in water that is near freezing. Several nails should be kept in water of normal room temperature.

A. Let the subject be blindfolded. Make a tiny red ink spot on the palm of the subject's hand. Using forceps if necessary to handle the nails, the observer will take one of the three kinds of nails and lightly touch the marked spot. The subject will report the temperature as he feels it.

Repeat with other nails, using all three kinds until 10 tests have been made of this one spot. Be sure to vary the order in which the nails are used so the subject will have no basis for guessing correctly. Remember that one-third of the answers might be correct and still be nothing but guess.

If 5 out of 10 trials are incorrectly answered, call this a neutral spot and pass on to another spot about an eighth of an inch away. Test it 10 times.

B. If the answers for any one spot are correct 5 times out of 10, call this a sensitive spot and test it until *each kind* of nail has been tried on it at least 10 times. Vary the order in which the nails are used, and keep your record by making a stroke in a table similar to the one below. From this you can decide whether to call this a hot spot, a cold spot, or a normal spot. Leave normal spots red, mark hot spots with black, and cold spots with ink of some other color.

Temperature Spots on Palm of				
Spot No.	Hot Spot	Cold Spot	Normal Spot	Conclusion
1				
2				
3				
4				

Proceed to test in this way until 20 or 30 sensitive spots are located on the palm of each student.

Similarly explore for temperature spots on the back of the hand of each student.

If time allows, make similar explorations on the tip of a finger, the arm, the back of the neck, or the cheek.

Make an actual size diagram of each part of the body tested, using a rule to accurately place the temperature spots.

Questions.—How many sorts of temperature sense are there? How abundant are these sensitive spots in comparison with the area of the whole skin?

Compare the number of sensitive spots on each part of the body tested.

How and why does the common idea of our perception of hot and cold differ from the facts as you have scientifically determined them?

Teaching Note.—This exercise is commonly shortened by testing each spot with a single nail. But single observations are of indeterminate value, and each spot should be tested several times. Moreover, if we make allowances for the inevitable guesswork in such experiments—and reckoning that with three possible answers to each test, one third of them might be correct without indicating more than a guess—it becomes evident that the ten observations suggested in the outline are necessary to determine whether or not a given spot is sensitive to temperature stimuli. To determine which of the three temperatures affect the spot, three sets of ten observations will be necessary. If this exercise is to be used at all, let it impress the student with at least this much of scientific precision.

Behavior *or* Physiology
One laboratory period
Kinsey BIOLOGY, pp. 406, 74

TASTE AND SMELL

Object.—To discover the means by which we taste things, and the value of being able to smell things.

Materials.—For the class: Samples of as many as possible of the following: sugar, spices of several sorts, powdered cereals, fruit juices, salt, vinegar, beef juice, flavoring extracts, quinine, etc.

For each student: As many vials as there are samples to test. Gum labels for each vial. A medicine dropper. A handkerchief or cloth for a blindfold.

Procedure.—As the samples are passed around, each student will make small amounts of fairly weak solutions, preparing them in the vials and labelling each vial as it is made up.

Two students will now work together.

A. Blindfold one student (the *subject*). Using the medicine dropper, the other student (the *observer*) will place a single drop of one of the solutions on the subject's tongue, asking the subject to keep his tongue well out until he has written on a piece of paper what he thinks the solution tastes like. The observer may then copy this report into the table of observations. By using this method of reporting, it will be possible to determine which part of the tongue is most sensitive to each sample.

Repeat until each solution has been placed on four parts of each student's tongue: The front on the side, the middle front, the middle back, and the back on the side. Occasionally make the test with clear water. Work until each space is filled in a table similar to the one below, but do not try any one of the solutions twice in succession. If the subject finds that the taste of any solution lingers too long, he should drink water or rinse his mouth before trying the next solution.

Tests made on.....						
Solutions	With nose open				With nose controlled	
	Front middle	Front on side	Back middle	Back on side	Nose shut	Nose open
Water.....						
Salt.....						
Sugar.....						
Vinegar.....						
Quinine.....						
.....						
.....						

B. Repeat the exercise while the subject holds the nose tight shut. This time it will not be necessary to test more than the one spot on the tongue which the previous work indicated was most sensitive to the particular solution. The subject will report on each solution while the nose is closed, and then immediately report on the same sample with the nose open.

C. Repeat the exercise until each student has served as subject and as observer.

Questions.—How many distinct tastes can be recognized by the tongue without the help of the nose?

How many with the help of the nose?

How important, then, is the nose for "tasting" things?

Can you explain how the nose can smell things that are already in one's mouth?

Can you explain how a cold in the head would affect our ability to taste things?

Are certain parts of the tongue most sensitive to certain tastes? Which parts to which tastes?

Would it ever be possible to put a bit of salt, sugar, vinegar, or quinine in our mouths without tasting them?

Why do biologists prefer to speak of reactions to chemical stimuli, instead of reactions to odors and tastes?

Teaching Note.—The list should always include salt, sugar, vinegar, and quinine.

Behavior, Physiology, *or* Ecology
One special field period
Kinsey BIOLOGY, pp. 406–408, 143

PLANT SLEEP MOVEMENTS

Object.—To observe the positions of some leaves at night.

Materials.—For the class: A couple of oil lanterns, or several strong flash lights.

Procedure.—How much do you know of plants and animals after dark? Let us arrange with the teacher for a special trip some evening, an hour or two after sundown (at an earlier hour in early spring or late fall, at a later hour in late spring or early fall). We must wait until the evening becomes distinctly cooler than the day if we would observe the best of the plant sleep movements.

We need not go far afield. The lawns, gardens, and street shade trees in town, the weed patch or larger parks of the large city, and every roadside and thicket of the more open country will be profitable places for the trip.

By means of the lantern, examine just any of the plants with which you are familiar in the daytime. If you are keen, you will find that the position of the leaves of practically every kind of plant is different at night from the position in the day. Examine everything you find; the following is a list of only a few of the interesting items:

Many common grasses more or less double or roll their leaves lengthwise.

Cherry, apple, plum, and many others fold lengthwise a bit along the mid-vein. At the same time each leaf droops considerably, and dew is rolled off the tip.

The plantain leaves so common on lawns stand more upright, with edges inrolled, while the dew trickles down the trough-like leaf stem and waters the crown and roots below.

Common dandelion, daisy, and a great many common flowers close more or less after sundown.

Evening primrose, bladder campion, and a few others (usually common weeds) open their flowers after nightfall.

Maple and many others with radiating (palmate) veins, and blackberry, raspberry, Virginia creeper, sweet clover, and others with similarly radiating leaflets fold lengthwise along each main vein. Then they somewhat resemble a half-closed fan.

Clovers, wood sorrel (sour grass), alfalfa, vetch, and others with similarly clover-like leaves have some of the most marked night positions. Almost every species has its own method of tucking away its leaflets. Don't miss them in your search.

Perhaps most exciting of all are the leaves of locust, walnut, butternut, acacia, and other plants where the leaflets are many and arranged in a row on either side of a long mid-rib.

Once there was a lady who was raised in a house that snuggled behind a very large locust tree; but she had lived there two score years and some before she happened to see the night movements of those locust leaves I shall never forget her astonishment then!

—And has the trip been worth it? And will you need the teacher and the class along before you try to discover some more of these sleep movements?

What causes these movements? At some later time we shall have to experiment to answer this question.

Teaching Note.—This trip deals with such striking material that it should be planned if arrangements can possibly be made for the class to come together at the necessary hour. The success of the program may be guaranteed by locating a few of the more interesting species some day before the trip. The trip may be run at any growing season, from the first growth in spring to the first frosts in the autumn.

Behavior
One laboratory period
Kinsey BIOLOGY, pp. 405–408

MECHANICAL REACTIONS OF PLANTS

Object.—To observe some of the mechanical reactions of some plant tissues.

Materials.—Two spring clothespins (or 4 common clothespins). About 4 inches of new, unused twine. A fairly deep pan of water. Freshly cut stems with tendrils (Virginia creeper, or grape, or wild morning glory, or bindweed, or sweet pea, or some other plant with tendrils). A freshly cut flower stalk of dandelion, a stem of wild carrot, a leaf of common, broad-leaved plantain (or English plantain) or other similar plants.

Procedure.—Go out-of-doors and gather the necessary fresh plant material for this exercise. Place all the material with the cut ends in water until you are ready to use it.

A. Strip the dandelion flower stalk (with a knife or your finger nail) into 3 or 4 lengthwise pieces at least four inches in length. Submerge one piece in a pan of water, carefully watch the results and draw a diagram of the position the piece now assumes.

B. Fasten each end of another piece of dandelion with a spring clothes pin (or fasten each end between two common clothespins that are stuck one in the other). Place the pins and dandelion tissue perfectly flat in the water. Draw a diagram of the position the piece now assumes. What do you learn from this result that was not observable in the preceding part of this exercise?

C. With your finger nail, strip out some of the stringy fibers from a common plantain leaf, beginning at the broken end of the leaf stalk and carefully tearing the fibers out of the blade of the leaf. Observe these tissues in the air for a while. Place in water. What is the difference in behavior? What does the water have to do with it?

D. Repeat this experiment with a piece of epidermis carefully stripped from a wild carrot stem, or from a stem of some other plant.

E. Repeat with the piece of twine.

F. Now rub your fingers lightly along the tips of the tendrils of the Virginia creeper or of any other twining plant you have at hand. Note

results. Submerge the whole plant in water. Compare results with previous results in this exercise.

Questions.—Why do we call the twisting of these plant tissues a mechanical behavior?

Can you explain *why* the twine reacted to water? Then can you explain *why* the live plant tissues reacted? Be careful of your answers!

Of what advantage are these particular tissues to the dandelion flower stalk and the plantain leaf blade?

Behavior
One laboratory period
Kinsey BIOLOGY, pp. 408–413

TROPISMS IN FRUIT FLIES

Object.—To determine whether fruit flies respond positively or negatively to light, gravity, heat, moisture, and various odors.

Materials.—A bottle of about a dozen adult fruit flies, with wads of cotton for stoppers. A bit of well-ripened banana. Absorbent paper.

Procedure.— **A.** Hold one end of the bottle of flies toward the lighted window; reverse the bottle slowly. What do the flies do?

How often can you get them to respond?

How rapidly will they respond?

How else can you test their reactions to light?

Do individuals differ in their responses to light? Can you discover any explanation for this individual variation?

B. Can you devise some way of testing the fly's response to gravity? Can you be sure they are not reacting to a light stimulus instead of gravity? Determine how often and how rapidly they will respond to a gravity stimulus.

C. Similarly test their response to heat in some way which you will devise. Be sure they are responding to temperature alone, and not to some other stimulus.

D. Place a wad of moistened paper in one end of the bottle of flies. How are the flies affected by it? Prevent all other stimuli from affecting the insects as you test them for the moisture reactions.

E. Place a bit of well-ripened banana at one end of the bottle of flies. How do they respond? Now, while the banana is still in the jar, make tests once again on the insect's reactions to light and to gravity. What do you conclude about the behavior of an animal that is affected by several stimuli at once?

Questions.—Why do we call tropisms "mechanical behaviors"?

Do you think fruit flies show any reasoning in their response to light? Discuss.

Why do we refer to most mechanical behaviors of animals as adaptations? Show this from your experiments with the fruit flies.

Do you think the tropistic responses of these fruit flies might sometimes prove harmful to the flies? Discuss.

Teaching Note.—Wide-mouthed bottles 2¼″ in diameter and 5½″ in height are standard laboratory equipment; half-pint or pint milk bottles are satisfactory substitutes. Such bottles, placed out-of-doors (especially near groceries, markets, or kitchen pantries) with a small piece of well-ripened banana in each, will attract the small, gnat-like, honey-colored fruit flies in numbers within an hour or two on a clear day. Compacted wads of cotton, quickly stuffed into the mouths of the bottles, will trap the flies. To transfer the insects from bottle to bottle, turn a bottle of flies *away from* the source of light, take out the stopper and quickly cover the mouth of this bottle with the mouth of a second bottle. Now by turning the bottles toward or away from the light, the movement of the insects from one bottle to another may be largely controlled.

Behavior
One laboratory period
Kinsey BIOLOGY, pp. 408–413
Requires early preparation

TROPISMS IN BLOWFLIES

Object.—To observe the reactions of blowfly larvæ and adults to light.

Materials.—A number of live blowfly larvæ. One or more live blowfly adults in a jar. Dissecting scissors. Forceps. Black ink. A paint brush. A sheet of paper. Twine.

Procedure.—**A.** Place a drop of ink in the middle of a clean sheet of paper. Dilute with a few drops of water. Place a live blowfly larva in the ink drop and note whether it crawls toward or away from the light.

Now turn the sheet of paper 90° and note the reaction of the larva. The ink which the insect is trailing over the paper will leave a record of its path. Will the larva turn when the paper is turned? How often will it turn in a few moments' time? Try making the insect write your name. Dilute more ink and drop it on the back of the insect if its path becomes too dry.

B. Work in pairs on this part of the exercise, if live adult flies are scarce. Reaching the forceps down beside the cotton plug and into the bottle that contains a fly, catch the insect by the wings before you remove the plug from the bottle. Grasp the fly in your fingers, by its legs, without injuring it. Quickly cut off its wings with the dissecting scissors. This will hurt the fly just about as much as it hurts you to have your finger nails cut.

Now the fly will have to crawl. Let it crawl on a flat surface. Let it crawl on a vertical electric cord or piece of twine you may hang up. What are the fly's reactions to light?

Using the paint brush and black ink, paint over *one* of the eyes of the fly, making sure that the other is left unpainted. Now let the fly crawl

on a flat surface. Let it crawl on the hanging cord. Give the insect plenty of time to react. In each case, how does its behavior differ from its behavior when it had the use of both eyes? What does this show is the chief advantage of two eyes instead of one?

Teaching Note.—Blowflies are active in most localities from the first sign of spring until the fall frosts. Ten days or two weeks before this exercise, old fish heads or fresh (unsalted) meat should be placed with a few drops of water in a jar out-of-doors. Ordinarily the larvæ will be abundant in a few days, and the live adults cornered in these jars may, by the use of forceps, be picked out by the wings and kept in cotton-plugged jars until needed. Try moist sugar for food if these adults are to be kept more than a day or two.

Behavior *or* Morphology
One field or laboratory period
Kinsey BIOLOGY, pp. 406–413, 94

LEAF MOSAICS

Object.—To observe the positions of leaves on upright, on horizontal, and on slanting stems, and to find the factors that cause leaf mosaics.

Materials.—Several sheets of notebook paper. A drawing pencil. A piece of twine.

Procedure.—A. The vines, shrubbery, and trees in the school yard or nearby places will furnish plenty of opportunity for the observation of leaf mosaics.

If you can find ivy or some other vine on a wall, notice the arrangement of the leaves. Each receives the light largely without being covered by any other leaf. Such an arrangement of leaves is a leaf mosaic.

Examine the first 10 horizontal branches that you find on some tree, shrub, or stout-stemmed weed. Examine the first 10 that are nearly vertical. Examine 10 that stand out at about 45° from the vertical. Record how many of each shows a distin t leaf mosaic as you look at it from the side, from the tip end of the branch, and from directly above the branch.

Fill in a table similar to the one below. Record if possible the name of each plant examined.

Branches	Number showing good leaf mosaics		
	From the side	From the tip	From directly above
10 horizontal.....			
10 vertical.....			
10 at 45°.....			

B. Make two simple diagrammatic drawings showing the arrangement of the leaves on one of the smaller branches. In one drawing show the leaves as they appear from the side, and in the other drawing show the leaves as they appear from directly above the branch. In these drawings make sure to show the exact number and order of the leaves, although you may use a straight line for a stem and simple outlines to show each leaf.

Make two similar diagrams of the arrangement of the leaves on one of the smaller, vertical branches.

Make two similar diagrams of one of the smaller branches that stands out at about 45° from the vertical.

C. Before the end of the hour, let each student tie one or more growing branches in abnormal positions, for instance a normally horizontal branch in a vertical position, and a normally vertical branch in a horizontal position. Note results after two or three days.

Questions.—Did you see the mosaic on any branch from more than one position? How can you explain that?

Is there anything in your results that proves what causes a leaf mosaic?

Explain why it is so important for each leaf on a plant to adjust itself as it does in a mosaic. What happens to a leaf that fails to adjust itself so?

Teaching Note.—If fieldwork must be omitted because of local difficulties, the teacher may supply a more limited amount of material and work most of this exercise in the laboratory. Keep the material fresh in water, placing the stems in about the same relations to the light that they had in the out-of-doors.

Behavior
One laboratory period
Kinsey BIOLOGY, pp. 408–413, 86–88

TROPISMS IN EARTHWORMS

Object.—To determine how sensitive earthworms are to light, heat, pressure, and sound.

Materials.—An empty cardboard box (shoe box or smaller). Another box or small tin can of earth. Two or three live earthworms.

Procedure.—A. Place the live earthworms on a sheet of moist paper and see if they crawl toward or away from the window (or other source of light). Reverse the sheet of paper. Do the worms respond to the changed direction of the light? Is the response as rapid or as exact as in the fruit flies, blowflies, or other animals whose tropistic reactions you have observed?

B. Moisten the bottom of the cardboard box. Place one or more worms inside at one end, and one or more worms in the other end. Cover one end of the box, exposing the other end to the light. Do the worms show any response? Let the apparatus remain in this position at least five minutes, and note results.

Now switch the cover to the other end of the box. What is the immediate result? The result after five minutes?

C. Where are the eyes of an earthworm? Then how can you expect the creature to be affected by light?

Take a sheet of paper and, without touching the worm, shade all but the head end of the body from the light and see how quickly it responds. Then cover all but the middle section of the body and note the result. Then cover all but the hind end of the body and note results. Which of these three parts of the body is the most sensitive to light?

D. Devise some means of testing the worm's sensitivity to heat. Be sure it is not a response to light that you are now observing. Compare the degree of sensitivity to heat with the degree of sensitivity to light.

E. How sensitive is a worm to touch?

With the blunt point of a pencil (or similar object) gently touch the animal on the head.

Try this with a dissecting needle. Is the response any different from the response to the more blunt point?

With either the pencil or needle touch a worm on every half inch or

so of the body. Do this slowly enough to have the worm recover from one stimulus before it is stimulated again. Which part of the animal's body is most sensitive to touch? Repeat this with a second worm? Do your results differ from those with the first worm?

F. Does the worm hear sounds of any sort? Devise some means of testing this point.

G. Gently jar the table on which the worms lie. Do they show any response? Jar the floor on which the table is sitting. Do the worms respond?

Questions.—Which of these behaviors would you call reflex, and which tropistic?

Why are such behaviors spoken of as mechanical behavior?

In what ways did the live earthworm show it was more than a mere machine?

If the earthworm had as specialized sense organs as a fly, would the organs be located in the same place they are in a fly? Or where the sense organs are in the human?

If there was an animal with the wings of a fly and the sense organs of an earthworm, would it find life more dangerous than life is to a fly or to an earthworm? Discuss.

Which of the earthworm behaviors observed in this exercise would be advantageous (adaptive) for the worm in its natural habitat? And which behaviors would not be adaptive?

Teaching Note.—This exercise will have more educational value if each student can provide his own box of earth with the live worms.

Behavior
One laboratory period
Kinsey BIOLOGY, pp. 414–425

INSTINCTIVE BEHAVIOR OF EARTHWORMS

Object.—To determine the way in which an earthworm burrows into the ground.

Materials.—For two students: Three cardboard boxes (or tin cans or jars), each two-thirds full of earth; one with loose and moist woods (or rich garden) soil, one with dry and compacted clay, and one with dampened but loose clay. About six live earthworms in a box of loose and dampened soil.

Procedure.—Two students will work together.

Do not take the earthworms out of the loose soil, in which you brought them to the laboratory, until you are ready to experiment with them. This will keep them in better condition to show their normal behavior.

Place two or more worms on the surface of the soil in each of the three containers. If not enough worms are available for this, experiment with the available worms on one soil, and then use the same worms on the next soil.

Note the exact time it is before each worm begins to burrow into the earth. Do not disturb the worms in any way, if you wish to observe normal behavior. Remember that patience, the ability to observe a live creature for long periods of time without disturbing it until it shows its normal behavior, is the chief source of our knowledge of this subject in biology.

If any of the worms actually succeed in penetrating the earth, very carefully observe by what means they are able to make their burrows. You should discover that they use two and perhaps three means. Write a careful description of each method.

Do you think the dryness or wetness of a soil has anything to do with a worm burrowing? If time is available, carefully test the worms on this point. Show your ability to devise your own experiments.

What stimuli do you think cause an earthworm to burrow into the ground?

Clearly explain why you would call this behavior instinctive instead of tropistic.

Your observations might be recorded in a table similar to the following:

Worm No.	On	Time worm begins to burrow	Min. required to completely burrow	Amt. of soil cast back
	Loose woods soil Dry, compact clay Loose, wet clay			

Behavior
One field *or* laboratory period
Kinsey BIOLOGY, pp. 414–425

INSTINCTS OF DOMESTICATED ANIMALS

Object.—To observe and analyze some instinctive behaviors of domesticated animals.

Materials.—None.

Procedure.—**A.** Field trip. Make the trip to a farm where there are numerous setting hens and chicks, or cattle, or horses, or hogs, or sheep, or other animals; or arrange to visit some house where there is a cat or dog, or rabbits or other pets; or visit the city zoölogical gardens.

Remember you are trying to observe the animal's normal behavior. Do not frighten it more than is unavoidable. Do not attempt to force it to do too many things. Be patient, and wait for the animal to do what it would naturally do.

Watch the way each animal behaves upon the arrival of the class. Note any signs of fear. What does it do when frightened?

If possible, watch each animal feed. Carefully note how it finds its food and how it handles it.

If young animals can be observed, pay especial attention to them and to the way the parents behave toward them. Note how adults of the same species, but individuals other than the parents, behave toward these young.

Let the class sit around, quietly and long enough to see what the animal does in the course of an average 10 or 15 minutes—even if it does nothing in particular.

Try to label each behavior observed as reflex, tropistic, instinctive, memory, or reasoning, or a combination of these. Identify the simpler behaviors of which each instinctive behavior is composed. You will have to prove your case if you think any of these is an intelligent behavior (memory or reasoning).

B. Laboratory. If any domestic pet, cat, dog, chicken, rabbit, guinea pig, etc., can be borrowed *with its owner* for this period, make the observations suggested for the fieldwork.

If no live animal is available, let the class consider the behavior of *dogs* by having each student report some case of interest that he or she has actually observed. Do not admit any case based on second-hand

information. Let the class analyze each case in turn as reflex, tropism, instinct, memory, reasoning, or a combination of these.

Let the class similarly discuss observed behaviors of cats, horses, cattle, or other well-known animals.

Keep a record of the cases studied and what sort of behavior the class decided to call each.

Teaching Note.—While laboratory observations will not satisfactorily substitute for the suggested fieldwork, it will sometimes prove impossible to run the field trip, in which case the laboratory work seems desirable.

Behavior
One or more field periods
Kinsey BIOLOGY, pp. 449–467

ANT NESTS

Object.—To observe some of the instinctive behavior of ants in their nest-building, care of the young, slave-making, etc.

Materials.—For the class: A large knife. A trowel. Paper bags.

Procedure.—Look for ants in fairly dry (but not barren) fields, on slight slopes with bare rock on the surface, and in open woodlands. In the Southwest and West there are also species in grassy spots in the deserts.

Look for ants especially under shallow and rather flat stones. They are not to be expected under very small stones. Deeper stones are not worth turning, for they do not warm through enough to attract ants. Carefully turn stone after stone until you find the deep grooves in the soil which are the passageways of the ant nest.

If ants are present, you must quickly arrange yourselves to watch them. Not all the class can get around one small ant nest at once, so we may want to divide into two or three groups for these observations.

Watch what the ants do when they are disturbed. Are there any eggs (small, pin-head bodies kept in clusters), or larvæ (small and grub-like), or cocoons (larger, elongate, smooth-covered) in the nest? Do not call the cocoons "eggs."

Are the eggs, larvæ, and cocoons all mixed together, or are they in distinct parts of the nest? What do the ants do with these younger stages as the nest is uncovered? Time them and see how long it takes them to move the younger stages. Note some of the clever ways in which they are handled. Very carefully dig down a little way into the nest and find where the ants have put their larvæ. Notice how clean the nest is kept.

After you are done watching the ants, turn the original stone back over the nest so the colony will not be exterminated.

In some of these underground nests you may find layers of paper-like material which the ants have made to cover their tunnels, or even to cover some of their runways above ground.

Watch for more than one kind of adult ant in each nest. If there are one or two individuals much larger than the others, they may be the queens (probably young queens unless they are deep in the nest). Or you may have uncovered two colonies living side by side. Perhaps one

of these belongs to a very tiny thief ant that lives in tiny tunnels and steals the food of the larger ant. Or this may be a colony containing guest ants or shampoo experts that live peacefully with the other ants.

There are some ants that nest in lawns, at the edges of sidewalks, and in vacant lots. You may find small piles of loose dirt marking the entrances to such nests. These colonies are small but worth digging into.

Carefully loosen the soil about dandelion roots, the roots of corn, and some other plants. On these roots you may find the ant "chewing-gum factories"—scale insects or plant lice on whose secretions and excretions small, light yellow, nearly blind ants are feeding.

If you can locate a number of plant lice on the young twigs of some plant, you are likely to find ants drinking the sweet excretions of the lice. Watch how the ants attend their "cows," being careful that you do not touch the stems on which they are feeding or in any way disturb the ants. Young poplar shoots, spiræa, chrysanthemum, and many other plants are commonly laden with these plant lice. Blackened leaves at the tips of the shoots will help you spot the work of the lice from some distance.

Locate a big mound-ant's nest. Watch the ants at work building it. Now put your hand down on the nest, or gently pound it with the flat of your hand. Watch what the ants do. Can you see them standing on their hind legs and spraying formic acid? Can you smell it? For the sake of science, be a hero and allow the ants to bite your hand so you can carefully observe how they spray the formic acid into the wound.

Are there both red and black ants in this mound? If so, it may be because the black ants started the nest and the red (really black and red) ants have stolen it and are gradually replacing the black ants.

Using the knife and trowel you may make a clean cut down into one of these mounds and see how it is constructed. This is one of the most interesting nest constructions we may observe.

In decaying stumps or logs that lie on the ground in more moist woodlands you may find colonies of big black carpenter ants. You may find many large queens, and drones, and workers of several sizes in a single colony. The large-headed workers are the so-called soldiers. The tunnels made by these ants in the wood will be especially interesting to examine.

Behavior
One laboratory period
Kinsey BIOLOGY, pp. 449–467

ANT ENDURANCE UNDER WATER

Object.—To determine how long ants can live under water.

Materials.—A half dozen live ants (or many more if possible). Two or three small vials with corks. Forceps.

For the class: Several watches.

Procedure.—If a stony field or other source of ants is nearby, the class may go out and collect a number of the insects at the beginning of the hour. Handle the ants without hurting them, using forceps, grasping them preferably by the legs or thorax. Place in dry, clean vials. (Or the class may have collected this material on a previous trip, or each student may have been asked to bring the live ants for this laboratory period.)

Let each student place all the ants he or she will use in a single vial. Fill it with water (don't let the ants escape) and cork. Note the time Invert and gently shake often enough to make sure the ants are kept under water and not floating on the top.

At the end of one minute remove one ant (or more if the supply warrants), lay it in a dry (and if possible a sunny) place, and note how many minutes it is before the ant revives.

Remove more ants at the end of 2, 3, 4, 6, 8, 10, 15, 20, 30, and 45 minutes, 1 hour, etc.—continuing as long as the supply of ants lasts, or time allows, or until *three* successive groups of ants have failed to revive after the drowning.

Do not call an ant dead until it has had all possible time to recover.

Use a table something like the following to record your data.

No. of ants	Time when drowned	Time when taken out	Min. under water	Time when recovered	Min. to recover

Questions.—Now can you give one reason for the ecologic dominance of ants?

What about the respiration of an ant under water?

Behavior
One or more field periods
Kinsey BIOLOGY, pp. 449–467

EXPERIMENTS WITH ANTS

Object.—To observe the behavior of ants under difficulties and their behavior toward stranger ants.

Materials.—For the class: One pair of forceps, a little vinegar. A vial with a cork.

Procedure.—Locate a mound-ant's nest for the following experiments. Carpenter-ant nests in decaying wood will occasionally serve our purposes.

If you disturb the ants too much you will not secure an intelligible result. Do not touch the nest in any way except as necessary for the experiment.

A. Kill a single large insect (grasshopper, cricket, etc.) and place it on top the nest where the ants may find it. How long is it before they do find it? Do they seem to spread the news among their fellows? Prove your answer! And how do they move so large a burden? Be careful not to disturb the ants. Wait patiently for results. You may have to visit the nest a day or two later for the final results.

B. Pour a little vinegar (or other strong-smelling liquid) on one corner of the ants' nest being careful not to let it spread too far. What signs do the ants show of being disturbed? Do they make any attempt to overcome the difficulty? Delegate some one in the class to return a day or two later to discover the final chapter in this story.

C. Secure some live ants from some other colony. Any species will do but if it is the same species you have in this mound your results will be more striking. Carefully drop one of these stranger ants onto the center of the mound, and watch results. Do not drop a second ant on the mound until the experiment is finished with the first ant. Then try dropping the others, one at a time, on the mound. How do the ants recognize that these are strangers?

Take some of the ants from this first mound and put them in a vial of water, shake the vial so they are thoroughly washed in the water, and keep them under water for a minute or two. Then drop them on the mound, one at a time. Are they received as members of the colony or as strangers? Can you explain why?

Behavior
One laboratory period
Kinsey BIOLOGY, pp. 449–467

MORE EXPERIMENTS WITH ANTS

Object.—To determine whether ants can swim or fall without injury and whether they will swim or fall.

Materials.—For two students: A few live ants (of any sort). A shallow dish of water. Two small stones (or other solid objects). A very small dish of water (watch glass, or glass castor cup from the furniture store, or fruit jar lid, or other dish). A piece of cardboard.

For the class: A watch or clock.

Procedure.—Two students will work together.

A. Place a stone in a shallow dish of water in such a way that a small, dry corner of the stone protrudes above the water while it is at the same time completely surrounded by water. Using forceps, place a few ants on the dry corner of the stone and record the time. Carefully note the behavior of the ants. Record the time at which each of the ants may leave the stone to swim on the water.

B. Drop a few ants, one at a time, on the surface of the water, doing this gently enough so they are not immediately drowned beneath the surface. Note the time. Can the ants swim? How? Note how many minutes it takes each ant to get ashore. Compare with the results of the first experiment.

C. In a very small, shallow dish of water, place a stone (or other support) with a flat surface standing higher than the sides of the dish. On this support place a disk of cardboard which is wider than the shallow dish. Ants placed on this disk will be prevented by the water from climbing off. Since the disk is wider than the dish, the ants might easily drop off the edge of the disk onto the dry table beneath. Build up something at the edge of the dish so a drop of only an eighth of an inch would set the ants free. Note the time, place some ants on the disk, observe their behavior, and note the time when each ant drops the short distance to the stand below.

Question.—Do the ants show intelligence in this behavior? Is it tropistic or instinctive behavior?

Behavior
One laboratory period
Kinsey BIOLOGY, pp. 468–475

PARASITES

Object.—To observe the peculiar structures of some parasitic plants and animals.

Materials.—Several parasitic plants and animals.

Procedure.—As the collection of parasitic organisms circulates through the class in the course of the period,

Examine each specimen,

Try to learn its host and

The way in which it attacks the host, and

Note what structures of normal organisms are absent or greatly simplified in each of the parasitic species.

Do any of these parasites show the disadvantages of being a parasite?

Write a brief report for each species (with or without drawings, as you may prefer).

Teaching Note.—The laboratory can easily accumulate a permanent collection for this exercise. Secure round worms from any laboratory that is dissecting cats (or from supply houses), and a few flukes or flat worms from the supply houses. Preserve the worms in alcohol. Many parasitic insects (bird lice, chicken lice, body and head lice, fleas, sheep ticks, cattle ticks, etc.) may be secured locally or obtained cheaply from supply houses. Glue the insects to triangular points of cardboard that are mounted on insect pins, or (better) mount them dry on a microscope slide in a drop of balsam with a cover glass on top. The more woody fungi and even some of the parasitic seed plants (dodder, Indian pipe, broom rape, etc.) may be secured locally and preserved dry in large envelopes. One or two specimens of each will serve a whole class.

Do not make this a microscope exercise. There is value at times in seeing things in their normal size and relations.

Behavior
One field period
Kinsey BIOLOGY, pp. 495–514

BIRD BEHAVIOR

Object.— To observe some bird habitats and feeding, flight, song, and other behaviors.

Materials.—A pencil and paper.
For the class: Two or three small-sized bird books.

Procedure.— Make the trip to a large city park, or to bushy fields, thickets or the edges of woodlands in more open country. At this season (late spring) birds are abundant and active enough to be easily observed at any hour of the day, even by larger groups of students.

No previous knowledge of birds is necessary before one can observe some of the things they do. In recording your observations, you may not be able to name some of the birds observed even with the help of some bird book; but if not, watch what your bird is doing and for the time call it Number 1, or Number 2, etc. Some day you will want to learn correct names for these birds.

Work in pairs, more or less independently, but do not go further away than the teacher indicates. See how many individual birds you can observe in the period. You need not be as interested in building a large list of the species you observe. It will be more valuable to watch many different individuals of a smaller number of species.

See how many blank places you can fill in a table like the one below.

Bird (*by name or number, list each individual separately*) . .	No. 1	No. 2
Habitat (*air, field, thicket, orchard, deep woodland, roadside, backyard, ground, etc*)		
Kind of food (*if you can observe it*)		
Feeding behavior (*food gathered out of air by pursuit from high branches, by continuous flight, from tree trunks, off of leaves, from surface of ground, digging in ground, etc.*)		
Flight (*soaring, rapid, continuous, short, rare, etc.*)		
Songs or call notes (*repeated, rare, not heard, given in flight, while perching, etc.*)		
Other behavior observed		

Behavior
One field period (contest)
Kinsey BIOLOGY, pp. 507–511

BIRD NESTS

Object.—To determine the number of birds that nest in a limited area.

Materials.—A pencil and paper.

Procedure.—This trip may be run in open country, or within all but the business sections of rural or suburban towns. Large city parks are also good territory for the trip.

The class will be divided into four or more groups, each with a leader.

Each group will choose a limited area about the size of a large city park or of two or three city blocks. (Or the teacher will assign areas.) Each group will study all the bird nests (old and new) they can find in the area. Credits to be awarded and the winning group to be determined as follows:

One point for each complete record of a nest found in the assigned area, giving location, shape, general size, materials used in the nest, and notes on any other point of interest.

One additional point on each nest correctly named.

One additional point for each nest if the group will guarantee that the nest was not touched or in any way disturbed in the course of this study.

Each student should keep a copy of the record of his or her group.

Total the number of nests found by the whole class. Select a couple of students who will find (from a map of the town or city) what proportion of the whole township, town, or city was covered in this survey—these students to report at the next session of the class. From this, find the total number of nestings that may occur in your town.

Questions.—What are some of the possible explanations for the larger number of nests reported from some of the areas.

How could you help increase the number of nests in your town?

Are bird nestings more abundant in your town than in the open, unsettled country?

What are the chief enemies of birds' nests?

Scientific Method
One laboratory period
Kinsey BIOLOGY, pp. 526-530

ADVERTISING ARGUMENTS

Object.—To discover whether scientific arguments are used in magazine advertisements.

Materials.—Two or more old magazines which contain numerous advertisements.

Procedure.—Study the advertisements in your magazines, classifying them according to the scheme indicated below. Add any other headings you think necessary. Many of the advertisements will need to be checked under two or more headings in this classification. Study as many as the time allows, but take time to study each ad thoroughly.

		Totals
Number of ads studied		
State superiority of products without arguments		
Give arguments without authorities		
Give as authority a single person unknown to you		
Give as authority a single, well-known person not qualified to judge this question		
Give as authority a single person who is an expert on the question		
Give more than one person as authority for the arguments		

Questions.—Do you think the advertisers are unscientific in their advertising, or the public unscientific in the way it buys—or both? Are the advertisers or the public most to blame?

Did you find that the best products (such as the best automobiles, the best electric fixtures, etc.) were most scientific in their arguments? Why is this so?

What types of products (foods, furniture, clothes, personal luxuries, autos, etc.) gave the most scientific arguments?

How can we help better the situation we have found here? These advertisements are a real measure of the way the *public* thinks, and you may want to give thought to this question for some years to come.

Scientific Method
One field period (contest)
Kinsey BIOLOGY, p. 527

AN OBSERVATION RACE

Object.—To test each student's ability to observe and to observe correctly.

Materials.—A pencil and paper.

Procedure.—Choose a familiar street or path, preferably one that is well-known to all of the class. Let it be about two blocks in length. The path will provide the most interesting material if it is in a suburban or more open country, but the game also proves profitable in the city streets.

Each student will work independently, making a list of as many different kinds of plants or animals as he can observe on the road or *on either side* of the road. The observer is not to leave the road itself. Use ready-made names for plants and animals if the correct names are not known to you.

In the city, let the list cover the especially interesting things that people are observed to do—or let the list cover the articles in a large and crowded store window.

One half hour will be allowed for these observations.

Let each student report the two or three most interesting things observed.

Let each student then report how large his list is—and stand ready if necessary to prove his list is sound.

Let the class realize how much more some folks see than others see. Let the class note every case where two people have apparently observed the same thing but saw it differently.

A FIELD SURVEY CONTEST

Object.—To determine the number of species of plants and animals in a limited area, and to test the student's ability to make observations.

Materials.—Three students in the class need pencil and paper.

Procedure.— Choose as wild a spot as is available, even if it is only a weed patch. It will be best if it has a wide variety of conditions and vegetation.

The class will be divided into three groups, each with a leader and a recorder. Each group will be allowed five minutes to choose an area 25 feet in diameter for their observations.

Then each group will start to make a list (to be kept by the recorder) of all the plants and animals they can discover in their area. Exact names need not be used; general names (*e.g.*, a red salamander, a green and white fungus, a small black beetle) will suffice. A limited number of the more unusual specimens may be collected to show in the final report.

Twenty or thirty minutes (not more) will be allowed for the contest. At the end of that time, the groups will come together to report. Each will report its most unusual discoveries. Then each will report the total number of species it found in its area. A group may be called upon to prove its observations accurate. The group with the largest accurate list will be declared winner.

Realize what large numbers of plants and animals you have found in these limited areas.

Note that few of the organisms were noticeable until careful search was made for them.

Also realize the value of *quick* observation, not only in this contest, but in much fieldwork in biology.

General
One field period

A DISCOVERY GAME

Object.—To test the student's knowledge of, and ability to observe some one kind of plant.

Materials.—None.

Procedure.— This game may be played on streets that are planted with shade trees, or along any road in more open country.

At the beginning of the hour, the teacher will announce the route along which the trip will be made.

Then the teacher will present a list of trees (or other plants or birds, if the class prefers) which will be used in the game. In the course of the trip, each specimen of one of the kinds of trees will count one point for some student, each specimen of another kind will count one point for another student, and so on. Some of the rarer trees will count two or three points each, as the teacher will designate (or the class decide at the start).

Each student in turn (his turn determined by the class list, or by some other means) will choose "his" or "her" tree.

The class will make the trip in a body. In order to make credits, each student must call attention to each specimen of his tree that he recognizes en route. Thus the student's ability to identify the particular kind of plant will be tested. Any student wrongly identifying his plant will have his credit reduced by one point.

The ability of the entire class will be tested by the checking necessary as each student makes his identifications.

General
One or more field periods
"That it is an interesting world in which we live."

SPRING FLOWERS

Object.– To observe the beauty and interesting biology of spring flowers.

Materials.—None.

Procedure.—No matter what part of biology we may be studying in the laboratory at this spring season, we should get into the fields and woodlands and let their magic convince us of the beauty of the world.

Make the trip to the wildest spot (preferably not too dry) within reach—the large city park if we cannot get further afield.

Observe as many of the newly awakened plants and animals as possible.

Observe especially those plants that have already reached their season of bloom. Examine them closely. This time we shall not dissect them, or count stamens and pistils, but note their beauty of form.

Does some one know the name of this flower? And of each other we shall find? If no one knows, we will take a specimen home to identify in some flower book. Meanwhile we will admire the flower without knowing its name.

And what interesting things do you know about each species? The students are running this field trip; the teacher will give you no information unless the class is unable to piece out the story by itself.

In the course of the trip carefully dig up one root of each species that is in flower. Be careful not to do extensive digging that would destroy any appreciable part of these colonies of flowers. By examining these roots, see if we can determine why certain flowers bloom in the spring while others wait until later—sometimes until much later in the year before they bloom.